Package of Organic Practices from Tamil Nadu

for

Rice, Groundnut, Tomato and Okra

Centre for Indian Knowledge Systems

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Real-world solutions from traditional science.

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Prepared by
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Package of Practices for Organic Cultivation of Rice, Groundnut, Tomato and Okra

Prepared by Centre for Indian Knowledge Systems (CIKS)
(September 2006)

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Preface

After the advent of the 'Green Revolution' and the introduction with it of chemical farming and high response varieties, several changes came about in agricultural practices. As a result, pest and disease attacks on crops increased to a great extent. The use of pesticides diminished drastically the number of beneficial organisms in the field. Insects also developed resistance to pesticides. Moreover, the chemical pesticides and fertilisers polluted the natural environment in various ways, causing a lot of health hazards. The fertility of the soil was also affected to a great extent.

The only solution to these myriad problems is to revert to organic methods of cultivation. Not only are these eco-friendly, they do not involve the use of any harmful chemicals.

Our organization – the Centre for Indian Knowledge Systems – is working in the areas of organic farming, vrkshayurveda and biodiversity conservation for more than a decade. It has been involved in research and has been providing training to farmers on organic farming practices. We also bring out a large number of publications for farmers and NGOs providing information on organic cultivation methods.

The Ministry of Agriculture (MoF) initiated a Technical Cooperation Programme (TCP) with the Food and Agriculture Organisation of the United Nations in 2005 in order to build a technical capacity base for the promotion of organic agriculture. Under this programme, CIKS was assigned the task of preparing the package of organic practices for rice, groundnut, tomato and okra for Tamil Nadu.

This package provides detailed information on various aspects of the organic cultivation of these four crops. Several of the techniques described in the package have been tested out on our own experimental farm and also in farmers' fields. We are really happy to have been involved in the preparation of this state level document for the FAO.

Chennai
September 2006

K.Vijayalakshmi
Research Director
CIKS

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INTRODUCTION

AGROLOGY OF TAMILNADU

Tamil Nadu is the southernmost state of India, surrounded by Andhra Pradesh in the north, Karnataka and Kerala in the west, the Indian Ocean in the south and the Bay of Bengal in the east. Geographically, the state is situated on the eastern side of the Indian peninsula, between the northern latitude of 8.5" and 13.35" and the eastern longitude of 76.15" and 80.20".

Agroclimate

The climate of Tamil Nadu is tropical in nature with a very minor variation in summer and winter temperatures. While April–June is the warmest summer period with the temperature rising up to 40 °C, November–February is the coolest winter period with temperature hovering around 20 °C, making the climate quite pleasant. The temperature in the plains ranges between 42.8–12.0 °C and in the hills the average temperature lies between 33.5–4.6 °C. Tamil Nadu gets most of its rains from the north-east monsoon from October and December. Rainwater is the basic resource for water availability in the state. The rainfall per annum ranges between 635 and 1,905 mm. Tamil Nadu is classified into seven agroclimatic zones: northeast, northwest, west, south, high rainfall zone, high altitude, hilly, and Cauvery delta zone.

Soils

Red loam, laterite, black, sandy, coastal alluvium and red sandy soil are the various soil types. Though red soil is dominant, both black and alluvial soils are also spread over the state next in extent to red soils. Traditionally, the land has been divided into five major physiographic divisions – the Kurinji or mountainous region, the Mullai or forest region, the Palai or arid region, the Marudham or the fertile plains and the Neidhal or coastal region.

Area and production of principal crops grown

Although Tamil Nadu is one of the most urbanized states of India, it is still largely rural. Agriculture is the mainstay of life for about three-quarters of the rural population. Out of the 13 million hectares of geographical area – which is 3.95 per cent of the total geographical area of India – the cultivable area is around 7 million hectares. Of this, 55 per cent is dryland. The total irrigated area is around 26,37,200 hectares. Canals, tanks, tube wells and open wells are the common sources of irrigation in the state. The main food crops are rice, maize, jowar, bajra, ragi and pulses. The cash crops include cotton, sugarcane, oilseeds, coffee, tea, rubber and chilies.

Area and production of the principal crops in Tamil Nadu

Crops	Area (Ha) (in '000)	Production ('000 tonnes)
Paddy	1873	5062
Millets and other cereals	824	868
Pulses	590	216
Sugarcane	222	24457
Groundnut	616	1005
Gingelly	73	34
Cotton (bales of 170 kg lint)	129	195

Source: Department of Economics and Statistics, Chennai 600 006.

Consumption of chemical fertilisers and pesticides

The total consumption of NPK fertilizers in the state is 10.52 MT. Pesticides consumption is 6,669 MT as dust and 5,53,242 litres in the form of liquid formulations. (*Source: Department of Agriculture*, Chennai 600 005).

Organic agriculture

Fertile soil is the basis of organic farming. A healthy soil with proper cropping patterns, crop residue management and effective crop rotation can sustain optimum production levels over the years without any loss in fertility. Organic farming envisages a comprehensive management approach to improve soil health, the ecosystem balance of the region and the quality of produce. It

includes all agricultural systems that promote environmentally sound production of food and fibres. These systems take local soil fertility as a key to successful production by respecting the natural capacity of plants, animals and the landscape; they aim to optimize quality in all aspects of agriculture and environment.

The fertility of the soil can be maintained by continuous incorporation of crop and weed biomass, use of animal dung and urine based manures (farmyard manure, NADEP compost, vermicompost), biofertilisers, bioenhancers (*amrut pani*, BD 500, *beejamrut*, *jeevamrut*, *panchagavya*) and other liquid formulations (BD 501, BD liquid manures).

In general, if soil is fertile and appropriate varieties are used, there is no infestation of pest and disease, but a large number of options are still available for effective management of these. These include sprays of BD 501, BD liquid pesticides prepared from cow dung and cow's urine mixed with certain organic materials and other formulations. In potassium deficient and acidic soils, some quantity of mineral grade rock phosphate and lime can also be used along with compost or directly in the field.

Habitat management

Management of an appropriate habitat for sustenance of different life forms is an essential component of organic farming. This can be achieved by maintaining crop diversity in the first place and by maintaining wide variety of trees and bushes as per climatic suitability. In plains, for a 10-acre farm, plant at least 5–6 neem trees, 1–2 tamarind, 8–10 *ber* bushes, 1–2 gooseberry/*aonla* (*Emblica officinalis*), 1–2 drumstick and 10–15 wild bushes. Major and minor plots should be planted with gliricidia plants. Lopping from these will provide enough quantity of biologically fixed nitrogen. A 400 m long gliricidia strip (1 ha boundary) can provide up to 22.5 kg of N/ha from the third year of planting and up to 77 kg of N/year by the seventh year.

These trees and bushes not only ensure nutrients from the air and from deep soil layers but also keep adding diversity to the nutrients and ensuring shelter and food to a wide variety of birds, friendly insects and pest predators. There may be some loss of productivity due to shading effect, but that loss will be more than compensated by reduced pest problems and by the creation of a natural biological pest control system.

Ecological diversity is an essential component of a successful organic farming system. It is also important to manage wildlife habitats as an integral part of organic farms. This includes areas such as banks, hedges, ponds, pasture areas and scrub land.

Converting soil to organic

For effective results, the conversion process should be started from the *kharif* season. With the first monsoon showers, the field should be ploughed lightly; 4–5 quintals of compost (NADEP/ vermicompost/ biodung) should be applied along with 50 kg rock phosphate, 5 kg each of azotobacter and PSB/ha and mixed well with the soil. For one hectare area, 500 litres of *amrut pani* or *jeevamrut* should be applied. This can be accomplished by sprinkling the solution over the soil surface during mild showers. Three types of legume crop of different duration should be selected for sowing in strips. These could be *moong* (60 days), cowpea, soyabean (120 days) and pigeon pea (160 days).

After every four rows of pigeon pea, one row of maize/jowar should be raised. Before sowing, seeds must be treated with 300 gm of appropriate *rhizobium* in case of legumes, and with azotobacter in case of maize/jowar for every 10 kg. After 20–25 days, a second dose of *jeevamrut* @ 500 l/ha has to be applied with irrigation or sprinkled over the wet surface after rains. *Moong* will mature in 60 days. After harvesting the pods, the *moong* residue can be used as mulch around the pigeon pea plants. This will conserve moisture and provide nutrients to the pigeon pea at grain formation stage.

Cowpea/soyabean will mature in 120 days. The pods should be collected and the residue should be spread out in the empty spaces: this can provide about 12–15 quintals of green leaves. Once the pigeon pea sheds its leaves in the field, the bushes should be cut for harvesting. Sufficient quantity of *jeevamrut* should be sprinkled over the crop residues and mixed with the soil.

Rabi season

A short to medium duration crop should be selected. The crop residues should be incorporated into the soil by ploughing and 500 litres of *jeevamrut* (per ha) should be applied to the soil. In case we choose a legume again (such as gram, green gram or lentil), there is no further need to add any other manure. If a cereal crop is being chosen, intercropping should be adopted (wheat-mustard-gram or wheat-mustard-safflower). Four to five quintals of compost should be added. Before sowing, the seeds should be treated with *beejamrut* and biofertilisers (azotobacter/*rhizobium*).

Two doses of *jeevamrut* should be applied along with irrigation water after 25, and 50, days of sowing. After the harvest, the grain should be removed and the crop residues left in the field as mulch to protect the soil from the effects of the harsh summer. If irrigation is available, summer *moong* can be taken up. In this way, by the next rainy season, the soil will be ready for regular crops.

Selection of crops

In organic farming, monocropping should be avoided and preferably 2–3 crops should be grown together. Where it is not possible in some cases to take mixed or inter-crops, different crops can be grown in adjacent plots to maintain diversity.

At any given time, legumes must occupy 30% of the total cropping area.

High yielding varieties require high nutrient inputs; they should be replaced with local varieties suitable for organic management.

The same crop or the same cropping sequence should not be repeated in the same field for two consecutive seasons or years (except for some legume crops such as *moong* or cowpea), and should be rotated in a 2–3 year's interval.

High nutrient demanding crops such as potato, radish, etc., must be preceded or followed by legumes or intercropping has to be taken in three years' rotation.

Field preparation

After harvesting, the residues of the crop should be spread over the field and *jeevamrut* should be sprinkled @ 500 litre/ha. The residue should be mixed into the soil with a rotavator or with the help of a bullock-drawn plough. While spreading the residue, one must ensure that at least one-third of the residue is from a leguminous crop. Optimum moisture should be maintained in the field. After two weeks, 4–5 quintals of compost and 500 litres of *jeevamrut* should be applied. If required, 300–400 kg rock phosphate can also be applied along with compost. In acidic soils, application of lime @100 kg/ha is also beneficial.

From the third year onwards, lopping of gliricidia will be available in plenty. These should be used as green leaf manure, as a component in compost or as mulch materials. For nutrient demanding crops in the *rabi* season, a mixture of chicken manure and oil cakes can also be used @ 1000–1500 kg/ha in addition to the above treatments.

Seed treatment

Beejamrut or white anthill soil and cow's urine in combination with *rhizobium*/azotobacter/biofertilisers are good seed treating agents. In case of root/foot rot and damping-off disease infested soils, use of *trichoderma viride* inoculants and azotobacter in a double dose has been found to be highly effective.

Seeds can also be soaked in diluted cow urine, or cow urine and *agnihotra* ash. In wilt-infested soils, use of azotobacter in double dose has been found highly effective.

Sowing

The right combination of 2–4 crops and some random trap crops should be selected to maintain diversity to keep pest attacks at bay. Some common combinations could be:

Kharif

Maize/jowar, pigeon pea, *moong*/cowpea

Cotton, pigeon pea, moong/cowpea, jowar/maize

Cotton, pigeon pea, soyabean

Maize, *moong*, soyabean/cowpea

Rabi

Wheat, mustard, bajra

Barley, gram, mustard

Wheat, mustard, safflower

Moong, tomato, mustard

Vegetable crops with *moong*/french bean in between

Crops chosen and reasons

Rice

It forms the staple food for more than 65% of the population of India.

It is cultivated in a large area of 44.6 million hectares.

Large amounts of pesticides are used for its cultivation: the annual amount spent on pesticides for rice surpasses pesticide purchases for any other crop (*Source: IRRI*).

The cost of chemical inputs used for cultivation is high.

Groundnut

It is one of the most important oil seed crops of south India

It is cultivated over a large area of 8 million hectares in the country. (India stands first in world acreage of groundnut.)

Oil cakes from groundnut find wide uses as manure, cattle feed, etc.

Okra and tomato

These are among the important vegetable crops of the country.

They are cultivated over a large area. Okra is cultivated in about 3.4 lakh hectares. It is also the sixth most important vegetable in India.

Tomato is cultivated in about 4.7 lakh hectares and is widely used in a number of commercial preparations like jams, pickles, ketchups, etc.

Moreover, large amounts of pesticide are used in pest management for both.

RICE

Tamil: *Nellu; arisi*

BACKGROUND TO THE CROP

The Agricultural and Processed Food Products Export Development Agency (APEDA) is encouraging the rice sector to produce and export organic rice, especially basmati, to European countries. Returns from organic farming of rice could be maximized by management practices and judicious use of inputs. India is bestowed with a rich diversity of aromatic rices: among them, the long-grained, superfine, aromatic basmati rices are a unique 'gift of nature'. Basmati rices which cook with a pleasant fragrance enjoy a preferential price treatment both in domestic and international markets (Mishra, 2005). It is essential that farmers, millers and traders accept and meet the requirements of importing countries.

Rice, or rather paddy (*Oryza sativa*), is an important member of the family *Graminae*. It is a plant of Asian origin and the second-most important crop in India, next only to wheat. It forms the staple food of more than 65% of the population. Almost 90% of the world's total rice production comes from Asia. Among the Asian countries, China and India remain the world's top two rice producers. Cultivated rice belongs to two species: *O. sativa* which originated in Asia and *O. glaberrima* which originated in West Africa. Of the two, *O. sativa* is by far the more widely utilized. Asian cultivated rice has evolved into three eco-geographic races – *indica*, *japonica* and *javanica*. More than 600 improved varieties of indica rice have been released for cultivation since 1965.

Distribution

The major rice growing states in India are Uttar Pradesh, Madhya Pradesh, Bihar, West Bengal, Orissa, Andhra Pradesh, Assam, Punjab, Tamil Nadu, Karnataka, Maharashtra, Haryana, etc.

Area and production

Worldwide, paddy is cultivated over a total area of 152 million hectares with an annual production of 593 million tonnes with an average productivity of 3.91 tonnes/ha. In India, rice is cultivated over 44.6 m ha with a production of about 90 million tonnes and ranks second only to China.

Climate

Rice can be grown in both tropical and sub-tropical zones. The crop requires a high temperature, high humidity and optimum moisture during its growth. The average temperature ranges between 21–35 °C. More uniform and warm conditions enable more than one crop to be taken per year. There are both photo-sensitive and photo-insensitive rice varieties, the latter having a shorter maturation period.

Cropping system

Crop rotation is an agronomic practice followed by farmers to make use of nutrients present in the soil in the best possible way. When the same crop is planted every season the soil becomes deficient in a particular nutrient that is utilized largely by that plant. This situation can be prevented by cultivating crops that have different nutrient requirements. When leguminous plants are cultivated, they trap the atmospheric nitrogen and convert it into a form that can be easily utilized by the plants. When the root nodules and leaves of these plants get into the soil, they increase its nitrogen content and help to retain the soil fertility.

In various districts of Tamil Nadu such as south Arcot, north Arcot and Chengalpattu, banana, sugarcane and betel are cultivated as alternative crops for paddy. Cultivating *Sesbania* as an intermediate crop between two paddy crops gives good results. The following sequence can be maintained.

Rice-based cropping system

Seasons	Samba (July–Jan.)	Navarai (Dec.–Mar.)	Sornavari (April–Aug.)
Crops	Paddy	Black gram	Sesame
	Paddy	Ground nut	Paddy
	Paddy	Cotton	–
	Paddy	Vegetables	Green manure crops (for seeds)

The crops are planned in such a manner that the nutrients used by the first crop should be replaced by the following crop. The nutrient requirement of the second crop should be different. This will help greatly to maintain the nutrient balance in the soil.

Soil

Top soil should be ideally 18–23 cm deep. While cultivating paddy, it is always good to study the type, nature and the nutrient content of the soil before adding nutrients. This can be done by having soil samples tested in a soil-testing laboratory. Manure can be applied based on the nitrogen, potassium and phosphorus content of the soil. In paddy cultivation, the yield will be high when the pH of the soil is between 5 and 6.5. The yield will be poor if the pH of the soil is below 5 or above 9. Alluvial soil, sandy clay and clayey soils are suitable for paddy cultivation.

VARIETIES

Systematic varietal improvement of rice began at the rice research station, Dhaka (now in Bangladesh) in 1811 with pure line selections (Singh, 2005). The Central Rice Research Institute (CRRI) at Cuttack was established in 1945. This was the centre for the *indica-japonica* hybridization programme. Enhancing and stabilizing the grain yield potential with suitable plant types in different ecological conditions was the major objective of the rice improvement programme. Grain yield, grain length, cooking and eating quality are taken into consideration for developing ideal varieties. A good number of varieties combining earliness, resistance

to biotic and abiotic stresses and grain quality have been developed. Besides these, a number of local varieties suitable for various situations are still preferred, particularly by organic growers. In Tamil Nadu the following varieties are being cultivated:

Varieties resistant to drought

Kattu Samba, Sornavari, Puzhudikar, Puzhudisamba, Mattakkar, Vadansamba, Kullakkar, Gil Gil Samba, GEB – 24, Kuzhiyadichan.

Varieties resistant to water logging

Neelansamba, Kudiraival Samba, Kaliyan Samba, Samba Mosanam, Perungar, Koomvazhai, Kudaivazhai

Varieties resistant to both drought and water logging

Kappakkar, Vaigunda, Pichavari, Kurangusamba

Varieties suitable for saline soils

Karuppu nel, Samba, Kuzhiyadichan

Varieties resistant to pest and disease attack

Kappa Samba, Vadan Samba, Kudirai Vali, Kaliyan Samba, Kurangu Samba, Kichali Samba, Muttakkar, Kullakkar, Sigappu Kuruvikkar, Thooyamalle, Sembalai, Kallimadyan, Pitchavari, Sadakar

Variety resistant to brown plant hopper and ear head bug

Neelansamba

Variety resistant to brown plant hopper and rice caseworm

Sigappu Kuruvikkar

Variety resistant to weeds

Vaigunda

SEED

Selection of seed

Seed selection plays an important role in paddy cultivation. The seeds selected for cultivation should be of uniform size, age and free of contaminants. They should also have good germination capacity.

Separation of quality seed

To separate good seed from bad, soak them in water: the unviable seeds will float on the surface of water. These seeds can be easily

removed and the seeds that sink can be used for cultivation. By this method, damaged seeds are easily removed.

Another method is used when there is an excess of chaffy grain in the seed stock. Take some water in a vessel and drop an egg in it. Keep adding salt slowly till the egg reaches the surface. When the seeds are dropped into the water, the good quality seeds will sink. Remove the unviable seeds that float on the surface of the water. Wash the selected seeds in good water 2–3 times to remove the salt deposits. If this is not done, the germination capacity of the seeds will be affected.

Seed rate

The seed rate varies according to the variety to be cultivated. The seed rate required for one hectare of land under irrigated condition is given below:

Short duration variety	:	60–70 kg
Medium duration variety	:	40–60 kg
Long duration variety	:	30–60 kg
Dry and rain fed sowing	:	85–100 kg

Germination test

The germination test is considered the most important quality test for evaluating the planting value of a seed lot. The test is designed to measure the ability of seeds to produce normal seedlings and plants later on. The various ways of performing a germination test are listed below:

Tie a handful of seeds in a white cloth, soak it in water for 12 hours and keep in a dark place for 24 hours. Check the germination percentage the next day.

Tie paddy straw together to make it into a mat. Keep the seeds in the centre of the mat and then roll and tie it. Dip it in water for a minute and transfer the seeds to straw. After 24 hours, count the seeds that have germinated.

Take a wet gunny bag, fold it, put the seeds in between the two layers and keep the bag in the dark for a day. Check the germination the next day.

Treatment

Seed treatment helps to improve germination potential, vigour, and resistance to pests and disease. The different methods of rice seed treatment are:

Soaking the seeds in water

Tie the seeds in a small gunny bag or cloth bag and soak it in water for 12 hours. Later, remove the bag from the water and cover it with a moist gunny bag. The following day, soak the seeds in water for eight hours again. Later, remove the seeds from the water and sow them in the nursery. This method helps to improve the germination capacity of the seeds.

Using cow dung solution

Treating paddy seeds in a cow dung solution enhances their germination. Take ½ kg of fresh cow dung and two litres of cow urine and dilute them with five litres of water. Soak 10–15 kg seeds first in water for 10–12 hours and then in the cow dung solution for 5–6 hours. Dry the seeds in the shade before sowing them in the nursery.

Using goat dung solution

Treating 30-day old seeds for one day in a goat dung solution increases their germination.

Using cow's urine solution

Dilute 500 ml of cow's urine in 2.5 litres of water. Tie the seeds in small bags and soak them in the urine solution for half an hour. Dry the seeds in the shade before sowing them.

Using sweet flag extract

Dissolve 1.25 kg of sweet flag rhizome powder in six litres of water. Tie the seeds in small bags and soak them in the extract for half an

hour. Dry the seeds in the shade before sowing. (This is the quantity required for treating seeds to be sown in one hectare.)

Using *Salvadora persica*

Spread the leaves of *Salvadora persica* at the bottom of a closely-knit bamboo basket, then fill it with seed and pour about 10 to 12 litres of water over the basket. Cover the basket with the *Salvadora* leaves and place a weight over it. Leave the seeds undisturbed for 24 hours. The seeds are then ready to be used for sowing in the nursery. This procedure helps in early and vigorous germination. Treatment of rice seed with *amrut pani/panchagavya/cow pat pit manure/jeevamrut* is also effective. The efficiency needs to be evaluated.

Using biofertilisers

Biofertilisers like azospirillum/azotobacter/pseudomonas (@ 1.25 kg/ha) are first mixed in one litre of cooled rice gruel. Spread the sprouted seeds on a clean floor, add the biofertiliser slurry and mix well. The mixing of seed and biofertiliser slurry can be done in a pot as well. Dry the seeds in the shade for 30 minutes before sowing.

Drying the seeds for half an hour in the bright sun before sowing improves germination and seedling vigour.

CULTIVATION

Preparation of the nursery bed

Around 800 m^2 nursery area is required for raising seedlings needed for one hectare of land. After ploughing the nursery bed (four times), spread neem leaves on the soil. The leaves should be allowed to decay in water for 6–7 days. When the leaves decay completely, the land should be ploughed again four times and levelled. In case neem leaves are not available, 8–10 kg of neem cake and 10–15 kg of vermicompost should be added to the soil during the last ploughing. Later, the soil should be leveled and the seeds sown. Farm waste and trash can be burnt on nursery beds. The heat generated by burning sterilizes the soil and nutrients like potash

also get added. Leaves of *Adhatoda vasica* can be incorporated into the soil while preparing the nursery. This increases soil fertility; acts as an insecticide and renders the uprooting of the seedlings easier.

Note: One may encounter many weeds if farmyard manure is added to the nursery. Hence, it is advisable to avoid it.

Managing problem insects and disease in the nursery

Pests such as the green leaf hopper, green horned caterpillar and diseases such as brown leaf spot and blast generally attack seedlings in a nursery. Hence, the crop is damaged at its very early stages. These attacks can be prevented by spraying two doses of 10% cow's urine extract at seven days' interval at the appearance of the first symptom. This should be immediately followed by pest management techniques. Before plucking the seedlings, the nursery should be irrigated and 15–20 kg of gypsum should be added to prevent damage to the rootlets.

Application of biofertilisers

Azospirillum (@ 2.5 kg/ha) is mixed with 25 kg of farmyard manure and applied in the nursery 30 minutes before plucking. The seedlings are kept submerged in the nursery for 30 minutes and then transplanted.

Main field preparation

The main field should be irrigated and ploughed several times. The bunds should be trimmed and plastered to prevent water leakage. Rat holes found in the field should be sealed. Groundnut or neem cake (@15 quintals/ha) should be applied as basal manure during the final ploughing and the land should be levelled before sowing. At the time of the final ploughing, dried cow-dung and ash mixture can be spread uniformly across the field. This facilitates aeration and activates the microbes in the soil.

Seedling treatment

The paddy seedlings can be treated with ash and neem seed mixture before transplanting. For this, the seedling bundles are kept in small plots of standing water mixed with ash and pulverized neem seeds from 30 minutes to an hour.

One kilo of ash and 500 gm of neem seed are sufficient for treating 50 bundles of seedlings.

The treated seedlings produce a crop free from pests and disease.

Soak groundnut cake and neem cake in water overnight and filter. Treat the seedlings in this solution before transplantation. The treated seedlings are less vulnerable to pest attack.

The paddy seedlings can also be dipped in a solution of *amrut pani/ panchagavya/jeevamrut.*

Transplantation

The paddy seedlings are transplanted @ 2–3 saplings per hill at a depth of 3 cm. The spacing between the seedlings will vary according to the variety cultivated. Before transplanting, clip off the tips of the seedlings. This facilitates uniform growth and helps to remove egg masses and insect pests present on the leaf-tips.

Note: With old seedlings, varieties with low tillering capacity and soil with very high pH, lesser spacing should be given while transplanting and larger number of seedlings should be used (5–7 seedlings per hill).

Spacing

Short duration variety	–	15 x 10 cm
Medium duration variety	–	20 x 10 cm
Long duration variety	–	20 x 15 cm

Weeds

Weeds compete with rice and take away a heavy toll of energy, water and plant nutrients. Generally, they are found more in upland rice than in low land or irrigated rice. Weeding should be done manually and the picked weeds should be trampled into the field for *in situ* conservation of nutrients and for organic matter as mulch. The first weeding should be done at about 15–20 days after transplantation. About 50 kg neem cake should be applied to the field. Subsequent weedings should be done as and when weeds appear and become problematic. Weeds can be kept under check by flooding the field to a height of 5–8 cm during the early vegetative

stages. The most commonly found weeds in transplanted rice are *Echinochloa colonum, Echinochloa crusgalli, Cyperus iria, Eclipta alba, Celosia argentia, Dactyloctameum, Setaria glauca, Monocharia spp., Cyperus difformis, Scirpus spp., Fimbristylis litoralis, Marsilea quadrifolia,* etc.

Use of calotropis (*Calotropis gigantea*) as green manure checks the growth of the weed *Marsilea quadrifolia*. The fibrous pericarp of coconut applied @ 25 baskets/ha also controls this weed to some extent. It releases a tannin-like substance that inhibits the growth of the weed.

While preparing the land, apply leaves and small twigs of *Strychnos nux-vomica* (poison nut) and incorporate them into the soil. This helps to suppress the weeds.

MANAGING SOIL FERTILITY

From the day of sowing till harvest, the plants take in several nutrients from the soil. It is therefore essential to replace the used nutrients back in the soil for the next season crop and to retain soil fertility. The nutrients required by the plants can be supplied from organic sources such as farmyard manure, green manure, green leaf manure, vermicompost and biofertilisers.

These manures help prevent soil erosion and also improve the infiltration capacity of the soil.

Farmyard manure

Wastes of cattle, goat and pig are generally used as farmyard manure. All the nutrients required by the plants are present in small quantities in this manure. They remain in the soil for longer periods and produce good results.

Required quantity

Cow dung	–	12–15 tonnes/ha
Goat dung	–	12.5 tonnes/ha
Poultry waste	–	5 tonnes/ha
Pig dung	–	2.5 tonnes/ha

Method of use

Any one of the above mentioned manures should be applied as a basal manure during the final ploughing. The farmyard manure should be allowed to decay before it is used. The manure should be applied and ploughed into the soil the same day. When farmyard manure is allowed to remain in the field without incorporation into the soil for longer periods, there are chances that more than 50% of the nutrients will get wasted due to soil erosion and high temperature.

BIOFERTILISERS

The atmosphere contains about 78% nitrogen. Some of the microorganisms found in the soil fix atmospheric nitrogen and convert it into a form that can be early absorbed by plants. Some of the microbes that are commonly used in paddy cultivation for the purpose include azotobacter, azospirillum and phosphobacteria. They not only reduce the cultivation cost of using chemical fertilizers but also increase the yield and improve the fertility of the soil.

Plant growth regulators

Panchagavya

This is a growth regulator produced from a combination of five products obtained from the cow fermented along with a few other bioproducts. For coarse varieties, one spray of 3% *panchagavya* should be given during tillering and bootling stage.

For fine varieties, one spray of 3% *panchagavya* should be given during the bootling stage.

Amirthakaraisal

About 1,250 litres of *amirthakaraisal* should be mixed with irrigation water for a one-hectare crop. When it is used as a spray, 25 litres are required. This improves the soil fertility and gives good yield.

Green manure

These crops are generally cultivated in the field before cultivating the main crop. They are ploughed into the soil before flowering. Green manure is an essential organic manure for paddy. Plants belonging to the family *Leguminosae* are commonly used for the purpose. These plants absorb atmospheric nitrogen with the help of certain microorganisms found in their root nodules and convert it into a form which can be used by the plants. These plants should therefore be cultivated before the main crop.

Method of application

Green manure plants such as sunhemp, *daincha*, Indian indigo should be planted before the paddy season. They should be ploughed into the soil 45–50 days after sowing. The plants should be allowed to decay in the water for ten days and then ploughed.

Uses of green manure

Cultivation of green manure plants between two cropping seasons prevents soil erosion from rain and wind.

As the plants decompose they convert unavailable forms of calcium, phosphorus and micronutrients present in the soil into a form that can be easily absorbed by the plants.

In clayey soils, these plants help in increasing the soil's porosity by loosening its particles. They aid in enhancing the aeration and infiltration capacity of the soil.

When green manure plants are ploughed into the soil, they decompose and increase its carbon as well as its humus content.

These plants are also cultivated as trap crops and for fodder.

Commonly used green manure plants

Sunhemp (*Crotalaria juncea*), *daincha* (*Sesbania cannabina*), Sesbania (*Sesbania speciosa*), Wild indigo (*Tephrosia purpurea*), Indian indigo (*Indigofera tinctoria*), *Tephrosia noctiflora*.

Green manure

Green leaf manure

It is a common practice among farmers to plough in the green leafy twigs of certain plants into their fields. The leaves used for this purpose are termed as green leaf manure.

Uses of green leaf manures

The leaves of these plants are used both as green leaf manure and in the preparation of certain biopesticides. They help to increase the nitrogen content of the soil and minimize expenses towards pest management.

Commonly used green leaf manure plants

Azadirachta indica, Pongamia pinnata, Morinda pubescens are some of the commonly used green leaf manure plants. The siris tree *(Albizia lebbeck*), the gigantic swallow wort *(Calotropis gigantea*), spotted gliricidia *(Gliricidia sepium*), Tanner's cassia *(Cassia auriculata*) and white gulmohar *(Delonix elata*) are other green leaf manure plants.

Oil seed cake

The pith left behind after oil extraction is commonly called oil seed cake and it is a good source of organic nitrogen. There are different kinds of oil seed cakes available such as groundnut cake, neem seed cake and castor seed cake. Generally, neem and groundnut cakes are used for paddy. They supply the paddy crop with the nitrogen that is essential during its initial growth. The quantity needed is given below.

Cake	Basal manure	Top dressing
Neem seed cake	150 kg/hectare	60 kg/hectare
Groundnut cake	100 kg/hectare	25 kg/hectare

WATER REQUIREMENTS

There should be at least 2 cm of water in the field during transplantation. Water should always stagnate in the rice field. Maintain at least 3 cm of water from the tenth day till crop maturity. Water is required especially during the critical stages of tillering, flowering and milk formation. Top dressing should not be done in marshy fields where there is excess water stagnation. The water should be drained and the land should be allowed to dry before adding manure. Fields should be irrigated immediately after manuring.

The water requirement is higher in red and sandy soils. Hence the frequency of irrigation should also be higher in such soils. This can be managed by incorporating the plant *Ipomoea fistulosa* into the soil. When these plants rot, they enhance the water holding capacity of the soil.

Irrigation

Watering is unnecessary if during the first ten days, the field receives good rain. Avoid flooding if weeds can be controlled manually. Flooding is done to suppress weed growth and to increase nutrient availability, such as phosphorus, potassium, calcium iron and silica. Provide water only at critical stages, viz., (a) during the initial seedling period covering about 10 days; (b) during tillering to flowering, which is the most critical stage; (c) panicle initiation stage to flowering (heading). Flooding is not necessary if the soil is saturated with rains.

Until the transplanted seedlings are well established, water should be allowed to stand in the field at a depth of 2–5 cm. Thereafter, about 5 cm of water may be maintained up to the dough stage of the crop.

Water should be drained out from the field 7–15 days before harvest depending on the soil type to encourage quick and uniform maturity of grain.

Training and pruning

Two months after transplanting, the upper portion of the rice plants can be cut with a sickle. This checks excessive growth of the plants and also strengthens their base. By this, lodging is prevented during the maturity period, especially in waterlogged conditions.

PROBLEM INSECTS

Paddy crops are attacked by a variety of insedcts and diseases. A significant portion (10–51%) of our country's rice production is lost due to pest and disease attack. They decrease the yield to a great extent.

Insects that affect paddy cultivation can be classified into three major categories. They are:

Insects at different crop stages

STAGE	POSSIBLE AGENT
Seedling	Rice whorl maggot; thrips, defoliators; stem borers; green leaf hoppers, plant hoppers
Tillering	Thrips; defoliators, stem borers; green leaf hoppers; plant hoppers
Minor pests (vegetative phase): aphids, caseworm, black bugs, grasshoppers, mealy bugs	
Stem elongation	Defoliators; stem borers; green leaf hoppers; plant hoppers
Panicle initiation to bootling	Stem borers; green leaf hoppers; plant hoppers
Heading	Plant hoppers
Flowering	Plant hoppers; thrips
Minor pests (reproductive phase): Green horned caterpillars, skippers	
Mature grain stage	Plant hoppers; rice bugs
Minor pests (reproductive phase): Panicle mites	

Leaf eating caterpillars:

Leaf folder (*Cnaphalocrocis medinalis*)

Life cycle

The adult moth is small, brownish orange in colour, with wavy lines on the fore and hind wings. The female moth lays its eggs on the upper surface of the leaves. After seven days, pale yellowish green larvae emerge from these eggs.

In about 15–27 days, the larvae turn into pupae. After 6–8 days, adult moths emerge from the pupae.

Symptoms of attack

The leaves of the affected plant will be found rolled in the field. Eggs and larvae can be seen inside the folded leaf blades.

In a severely infested field, the whole crop gives a sickly appearance with white patches.

Damage pattern

The larvae cause longitudinal white streaks on the leaf blade, remain inside the leaf and feed on the leaf tissue. When infestation is severe, the leaves lose their chlorophyll content and turn pale; plant growth is affected and the yield of the crop is considerably reduced.

Management

- Spray 3–5% *Andrographis paniculata kashayam*.
- Spray garlic, ginger, chili extract.
- Spray 5% neem kernel extract.
- Spread leaves of *Sphaeranthus indicus* all over the field. The peculiar smell of this plant has the ability to repel leaf folders.
- Release ducks in the field to feed on the pests.
- Install 4–5 branches or twigs of fishtail palm or wild *Saccharum* in the field to attract predatory birds.
- Apply two cartloads of well decomposed farmyard manure before transplanting.

Rice case worm (*Nymphula depunctalis*)

Life cycle

The adults are small, delicate moths with white coloured wings. The female moth lays eggs on the upper surface of the leaves. Orange headed green caterpillars emerge from these eggs in about 2–6 days. The larvae turn into pupal cases in about 14–20 days. Thereafter, the adult moth emerges from these cases in 4–7 days.

Symptoms

The caterpillar cuts the leaves into smaller pieces. The damaged leaves hang as longitudinal rolls at the tip. Some of these can also be found floating on the surface of nearby water bodies. The larvae will be found inside the cut leaf rolls.

Damage pattern

The damage begins to show within 20–40 days of transplantation. The larva cuts the leaves into smaller bits and remains as a pupal case inside the cut leaves. It feeds on the inner tissue of the leaves.

Management

- Larvae found in the field can be controlled using the rope method.
- Spread chopped pieces of *Colacasia* and *Citrus grandis* in the field. They act as repellents.
- Drain water from the field for 3–4 days or apply raw cow dung to the standing water. This prevents the respiration of the larvae which is normally through rectal gills.
- Burn old worn out bicycle tyres during evening hours (light traps).

Green horned caterpillar (*Melanitis leda ismene*)

Life cycle

The adult butterfly is dark brown with a few black and yellow eye markings. It lays white round individual eggs on the upper surface of the leaves. The green coloured larva which hatches out of the egg has two red coloured horns. The matured larva turns into a green coloured pupa on the surface of the leaves. The adult butterfly hatches out of this pupa in 15 days.

Damage pattern

The larva mostly attacks the plants in the seedling stage and during the tillering stage.

Since these larvae attack the leaves as a group, plant growth gets severely affected.

Yellow hairy caterpillar (*Psalis pennatula*)

Life cycle

The adult is yellow in colour. The female lays its eggs on the surface of the leaves. Orange headed yellow coloured caterpillars emerge from these eggs. They have red stripes and tufts of hair all over the body. The two hairs in the front portion of the larva and the single hair at the back are found only when the caterpillar emerges. The caterpillars turn into pupae when they are fully grown. The pupae appear dull white in colour and silky in nature. The adults later emerge from the pupae.

Damage pattern

The larva infests the crop during the growing and the ear-head forming stage. Since the plant's leaves are damaged, the growth naturally gets affected.

Army worm (*Spodoptera litura*)

Life cycle

The adult moth is dark brown with a conspicuous black spot on the forewing. It lays 200–300 spherical eggs on the leaves and covers them with greyish hairs. Green coloured caterpillars emerge from these eggs in seven days. These caterpillars will attain their full growth in about 20–25 days. They are dark green or dull grey in colour with yellow back and side stripes. Pupation occurs in the soil and in about seven days, adult moths emerge.

Symptoms

The larva attacks during the night and eats away the leaves completely leaving behind only the midribs. Hence the infested crop gives an appearance of a field grazed by cattle.

Damage pattern

Plant growth gets affected when the infestation occurs at the early stages of the crop. If the infestation occurs in the later stages of the crop, panicles are cut at the base resulting in heavy grain loss.

Skipper (*Pelopidas mathias*)

Life cycle

The adult butterfly lays its eggs on the upper surface of the leaves. The larvae which are long and green in colour display a 'V' shaped dot on the forehead. They are found as pupae in the leaf folding. The adult butterflies are brownish in colour with two prominent dots on their forewings.

Symptoms

The leaves will be longitudinally folded.

Damage pattern

The larvae remain in the leaf folds and feed on the inner tissue of the leaves. This gives the affected leaves a skeletal appearance.

The infestation can be found both in the nursery and in the main field.

Economic threshold level (ETL)

Management measures should be implemented immediately when more than 10 leaves are damaged per hill.

Management of leaf eating caterpillars

- Neem cake is applied as basal manure. This prevents the entry of leaf eating caterpillars into the field.
- Five kilograms of Calotropis gigantea leaves are soaked in a mixture of ten litres of cow urine and five litres of water in a mud pot for 3–5 days. This is filtered and diluted with 80 litres of water and sprayed on foliage to control caterpillars.
- A simple way to keep away caterpillars is to have neem leaf bunches placed at different places within the field. These should be placed in at least twenty five places per hectare.

- The caterpillars can be easily controlled by using wood ash. For every hectare, 25 kg of wood ash should be mixed with sand and strewn in the field. This is a low cost technology which can be followed even by a small farmer.
- The field should be flooded and then drained. By this method, the larvae and pupae concealed in the soil can be exposed and removed.

Gall midge (*Orseolia oryzae*)

Gall midge affected rice plants

Life cycle

The adult fly is yellowish in colour. It lays about 100–200 elongated eggs on the under surface of the paddy leaves. Yellow coloured maggots emerge from these eggs in about 3–5 days. The larvae turn into brown coloured pupae in about 8–10 days. In eight days, the adult flies emerge. Their lifespan is about 1–5 days.

Symptoms

The terminal portion of the crop turns into a tubular gall. When the infestation is severe, the growth gets affected. Onion-leaf like tubular galls are found in the terminal portion.

Damage pattern

As the larvae and adults suck the sap, they insert a poisonous substance called 'sesitogen' into the leaves, after which the leaves roll and attain the shape of an elephant's trunk. The growth of the crop and ear-head formation are affected.

Economic threshold level (ETL)

When more than 10% of the plants in the field are infested, management measures should be immediately implemented.

Management

- Spread fresh leaves of *Cleistanthus collinus* (@ 10 kg leaves/100 m2 area) in the field at the initial stage of infestation.

Short-horned grasshopper (*Hieroglyphus banian*)

Life cycle

The adult grasshoppers are green in colour. Sometimes brown grasshoppers are also seen in the field. The adults lay eggs in the soil during October–November, preferably on the sides of the bunds. After seven days, nymphs emerge at the onset of monsoon rains. After 80 days, they turn into adults.

Symptoms

The insects damage leaves and also nibble the tender florets and grains. As a result, ear-heads turn white even before they emerge.

Management

- Spread *Calotropis* leaves beside the bunds of the field to prevent the entry of grasshoppers.
- *Sesbania aegyptiaca* can be grown as a hedge around the field.
- Brush the affected crop with branches of *Boswellia serrata* and place its twigs in the field at a distance of 6–8 m. This should be done in the evening after irrigation.
- A solution of cow dung or goat dung can be used. Take about 30–50 kg of the dung and put this in a gunny bag. The gunny bag is balanced on a pole. Below the gunny bag a drum is kept filled with 100–200 litres of water. The tip of the gunny bag should be kept in such a way that it touches the surface of the water. The gunny bag is shaken twice a day for 15 days. After 15 days the water in the drum will be brown and a foul smell will emerge. This should be diluted with twice the amount of water and sprayed. It acts as a repellant for grasshoppers.

Sap feeders:

Green leaf hopper (*Nephotettix virescens*)

Life cycle

The adults lay eggs under the epidermis of the leaf sheath. After six days, nymphs emerge. They turn into adults in about 16–18 days.

The adults are green in colour with black coloured dots on their back and they measure about 3–5 mm in length.

Symptoms

The tip of the leaves will turn yellow.

Damage pattern

The indirect damage caused by these insects is higher than the direct damage. The nymphs and adults remain on the leaf surface and suck its sap. Initially, the tip of the leaf turns yellow and gradually the growth gets affected. The insects also transmit the viral particles that are responsible for tungro disease.

Economic threshold level (ETL)

Sixty adults in 25 sweeps indicate that the pest has attained ETL. If more than 5 adults are found per hill during the vegetative stages or if more than 10 adults are found per hill during the flowering stages, management measures should be implemented immediately.

Management

- Before transplanting, treat the seedlings in neem seed kernel extract for 24 hours. This increases pest resistance.
- Neem oil and pongam oil should be mixed in the ratio of 1 : 4 and sprayed.
- The favourite egg laying spots of the pests – like wild grasses and weeds – should be removed from the field and bunds.

Brown plant hopper (*Nilaparvata lugens*)

Life cycle

The adults that are found in the soil lay about 200 eggs on the leaf lamina and leaf sheath. In about 10 days, dull white coloured wingless nymphs emerge from the white coloured eggs. The nymphs will measure about 3 mm in length. These nymphs gradually grow into adults in 12–18 days.

Symptoms

The crops have a burnt appearance.

Brown plant hopper adult

The affected crop dries up in patches.

While walking across the field, one can see hoppers flying about.

Damage pattern

The adults remain in the basal portion of the plant and suck its sap. Affected plants first turn yellow and later start drying up causing characteristic browning of the leaves commonly referred to as 'hopper burn'. The field appears as if burnt. As the insects move from one crop to another, they spill the sap on other parts of the plants as well. This results in the spread of sooty mould fungus. Hence stem rot disease is commonly found in fields affected by the brown plant hopper.

Economic threshold level (ETL)

If more than 15 pests are found per hill, the management measures should be implemented immediately.

Conducive atmosphere

Cloudy weather, excessively close spacing and heavy application of nitrogenous fertilizers favour the rapid multiplication and outbreak of BPH.

Management

- Use of high levels of nitrogenous fertilizers favours the increase of the BPH population. Hence such fertilizers should be used judiciously.
- Water stagnation should be avoided.
- Light traps can be used to monitor and attract BPH adults. The trapped insects can be killed
- Field and bunds should be cleaned of weeds thoroughly as these function as an alternate host for the insects.
- BPH can be controlled by practising the traditional '*neekal podum murai*'.
- The crops should be planted with proper spacing

- Leaf extract of *Lasiosiphon eriocephalus* (*nachinaar*) is effective in controlling BPH. One kg of the leaves is boiled in ten litres of water, filtered, diluted with water in the ratio of 1 : 10 and sprayed, once during the nursery stage and again after transplantation.
- Leaves of *Calotropis gigantea* can be spread in the interspaces and worked into the field.

Mealy bug (*Heterococcus rehi*)

Life cycle

Mealy bug adults are stout, round and whitish in colour. They lay about 100–300 eggs on the upper surface of the leaves and cover them with yellow coloured pupal cases. They are mostly found in the leaf axils. The nymph stage continues for about 17–37 days. Later, they turn into adults.

Symptoms

Stunted crops can be found in various portions of the field. When the infestation is severe, panicle formation is affected.

Damage pattern

The plants show stunted growth after the nymphs and adults suck the sap. The grain size gets reduced since the panicles are affected during the milky stage.

Conducive atmosphere

Dry spell and drought favour multiplication of the insect population.

Management

- Neem seed kernel extract can be sprayed.
- Burn the straw of *Paspalum scrobiculatum* and *Echinochloa frumentacea* near the affected field. Insects get drawn and die. They can also be picked physically and killed.

Earhead bug (*Leptocorisa acuta*)

Life cycle

Adults are brown with long legs. The female lays about 300 eggs on the leaf blade in long rows. Green coloured nymphs emerge out these eggs in about a week's time. They complete five nymphal instars and turn into adults in about 15 days. The adults live for about four months.

Symptoms

A foul odour in the field is an intimation of the presence of ear-head bugs in the field.

The pest infestation is severe during the milky stage.

Infested grains show characteristic brownish round dots.

Apply neem seed kernel powder (2–3 times).

Economic threshold level (ETL)

If more than five pests are found per 100 panicles, management measures should be immediately implemented.

Management

- The Cycas (*Cycas cercinalis*) flower – called *sannampu* in Tamil – is used to deal with this bug. It is cut and tied to a stick that is taller than the crop level. The stick is then placed along with straw in 10–15 places in the field. This arrangement repels the adult ear-head bugs and prevents their entry into the field for about two weeks. By this time, the milky stage is over and the crop attains maturity.
- *Achyranthes aspera* root (25 kg) and neem bark (12.5 kg) should be dried and powdered. This should be mixed with sufficient quantity of water and sprayed. This quantity is sufficient for one hectare of the crop.
- Broadcast kerosene (one litre) mixed with rice bran (4–5 kg).

Black bug (*Scotinophara coarctata*)

Life cycle

The adult bug is black in colour. It lays eggs on the surface of the leaves in two rows. After a few days, nymphs emerge.

As they move on the surface of the leaves, they feed on the chlorophyll content of the leaves. After molting five times, the adults emerge.

Symptoms

Blast lesions occur on the leaf and leaf sheath. The nymphs and adults feed on the chlorophyll content present in the central portion of the leaves. Hence the leaves break and then hang. The pest will persist in the tillers, leaves and terminal axils.

Damage pattern

The nymphs and adults remain on the under surface of the leaves and feed on the leaf tissue. When the infestation gets severe, the crop turns yellow and soon appears stunted.

Economic threshold level (ETL)

When more than five bugs are found or more than 10% of the leaves are damaged during tillering stage, the management measures should be immediately implemented.

Management

- Apply neem cake as top dressing to control the entry of beetles.

Stem borers:

Yellow stem borer – (*Scirpophaga incertulas*)

Life cycle

The adult female moth has a bright yellow forewing with a black spot. It lays about 200 eggs on the leaf tips and covers them with yellow coloured hairs. The eggs are flat and elongated. In about 5–8 days, tiny caterpillars hatch. They are green headed and light yellow in colour. In 28–30 days, they turn into brown colour pupae and in about 8–10 days, the adults emerge.

Symptoms

A hole made by the larva can be found on the under surface of the stem.

White chaffy ears can be seen at irregular intervals all over the field.

When the crop is infested at an early stage, growth and tillering is affected.

Damage pattern

Stem borers bore into the leaf sheath and damage the growing tip by feeding on the internal contents. This in turn disrupts the flow of water and nourishment to the plant thereby causing drying of the central shoot. This results in white ears. The larva can be found inside the central shoot. When infestation occurs during the growth stage, both growth and tillering get affected. When the infestation gets severe, the yield is affected.

Economic threshold level (ETL)

Occurrence of two egg masses or 2% white ears per m^2 indicates that the pest has attained the economic threshold level.

Management

- The land should be ploughed immediately after harvest to destroy eggs and pupae.
- Apply neem cake (42–50 kg) as basal manure.
- Neem cake bags can be placed in the irrigation channel.
- *Trichogramma* cards can be used. The egg cards of the parasitoids, *Trichogramma japanicam*, *Trichogramma presiliensis*, *Telenomus pelefecience* are available commercially.
- These parasitoids are capable of destroying the egg masses of stem borers.
- Male adult moths can be attracted and trapped using pheromone traps. Seven to eight pheromone traps should be

used per hectare. By this method the population of the insect pest can be controlled.

- The adult moths can also be attracted using light traps and then destroyed.
- The seedlings should be planted with proper spacing.
- Put branches of *Erythrina indica* in the field (3–4 m apart).
- Spray turmeric rhizome extract.
- Spread leaves and stems of *Datura* in the field and allow them to decompose. They act as repellents.

Crabs

Paddy crops are prone to attacks by crabs (after 30–35 days of transplanting) which cut the stems of the plant. They live in standing water or moist paddy fields and snip off the paddy stems. They also break the bunds by their burrowing. They can be controlled in the following ways:

Crush the flowers of *Butea monosperma* (*palas*) and place them near crab burrows. This reduces the damage to the crop.

Soak the seeds of *Tamarindus indica* (*imli*) in water for 24 hours and feed them to the crabs. About 5–6 seeds can be placed around each crab hole. The seed gets firmly lodged in the crab's mouth when it tries to eat it and this causes its death within a day or two. The seeds can also be broadcast on the field's bunds and hedges. Approximately 800 gm to one kg seeds are required for one hectare of paddy.

Apply raw cow dung @ 300 kg/ha in standing water. This will obstruct the movement of the crab.

General management of pests

- Place branches of *Calotropis* in the irrigation channel. The alkaloid present in the latex acts as an insect repellent.
- Boil leaves of *Vitex negundo* in water (about 30–40 kg of leaves in 10 litres of water) until it condenses to just one litre. To this, add 10 gm of asafoetida and five litres of cow's

urine. Mix well, filter and spray. Leaves of *Vitex negundo* can be broadcast in the field on observing the first symptoms of insect infestation, especially to control pests infecting root and stem in paddy.

- Broadcast leaves or seeds of custard apple (*Annona squamosa*). The smell of the leaves repel the insects. Leaves are used raw whereas seeds are processed and used as a powder.
- Cut the leaves of *Nerium oleander, Datura stramonium, Annona squamosa, Gloriosa superba* and fruits of *Strychnos nux-vomica* into small pieces and put them in a mud pot containing five litres of water. Cover the mouth of the pot with a lid and bury the pot inside a manure heap for a week. Later, heat the contents, allow it to cool, filter and spray. Two to three litres is needed for one hectare, sprayed at intervals of 10 days each.
- Beating an empty tin or drum or tying the carcass of a crow or a piece of black or red cloth to a end of a long pole at the time of maturity scares away birds and prevents them from destroying the grain.
- Take equal quantities of neem leaves and Cissus quadrangularis leaves, grind them together and soak in cow's urine for one week and then filter. Dilute the filtrate with water at 1 : 9 ratio and spray twice at intervals of 15 days.

BENEFICIAL INSECTS

Ladybird beetles

Three types of ladybird beetles are found in paddy fields.

Micraspis crocea – The body is oval shaped and brightly coloured in shades of red.

Harmonia octomaculata – Black spotted ladybird beetles that catch slow moving prey.

Menochilus sexmaculatus – They are more active and gregarious feeders.

Ladybird beetle

Ladybird beetles prey on brown plant hoppers, green leaf hoppers, aphids, leaf folders, stem borers, coccids and other soft-bodied insects.

Ground beetles (*Ophionea nigrofasciata*)

Ground beetles are active, hard bodied insects. Adults are reddish brown in colour with stripes spread over the body. An adult consumes 3–5 larvae per day.

They prey on leaf folder larvae, brown plant hoppers, green leaf hoppers, white backed plant hoppers, hairy caterpillars, green semiloopers and stem borers.

Crickets (*Metioche vittaticollis*)

Nymphs are pale brown in colour with stripes. Adults are black in colour.

Prey: striped and dark headed stem borers, leaf folders, armyworms, nymphs and adults of brown plant hoppers.

Damsel flies (*Agriocnemis pygmaea, Agriocnemis femina femina*)

Damsel flies are slender bodied, mostly red, orange, grey or bluish in colour. Adults fly below the rice canopy in search of flying insects as well as hoppers on plants.

Prey: brown plant hoppers, green leaf hoppers, leaf folders, white backed plant hoppers.

Earwig *(Euborellia stali)*

Earwigs are shiny, black in colour, mostly seen in dryland habitats and nest in the soil at the base of rice hills. Digging the soil is the best way to identify them. They enter the stem borer tunnels in search of the larvae.

Prey: stem borer larvae and leaf folder larvae. Each earwig consumes 20–30 larvae/day.

Long horned grass hoppers (*Conocephalus longipennis*)

They are green in colour with antennae 2–3 times longer than the body and are more active at night, seen mainly on leaves and panicles.

Prey: rice bugs, stem borer eggs, nymphs and adults of brown plant hopper and green leaf hopper.

Each predator can consume 1–4 yellow stem borer egg masses a day.

Water strider *(Limnogonus spp.)*

These are large, long legged, fast moving insects. Adults are black in colour with two pairs of hind legs. They are very fast swimmers and attack their prey quickly.

Prey: green leaf hoppers, brown plant hoppers, rice leaf rollers, armyworms and cutworms.

Fungal diseases:

Symptoms

Rice blast (*Pyricularia oryzae*)

This is an air-borne fungal disease. Small specks on the leaves enlarge into spindle shaped spots of varying lengths with a whitish grey centre and brown margins. Nodes and neck of the panicle blacken leading to breaking (neck blast) at the point of infection. The affected panicle breaks due to the weight of the grain. The symptoms occur from the seedling stage upto the third week of harvest. These symptoms can be seen in the stem. A black shaded region is seen above and below the node. When the infection occurs during the milky stage, the panicle gets poorly filled.

Management

- Crush the bark of *Careya arborea* (2–3 kg) and apply to the field.
- Boil one kilogram of tulsi leaves in two litres of water. Strain and spray the solution twice at 15 days interval (@ 2 ml per litre of water). Leaves of wild tulsi plants can be used for this purpose.

DISEASES

Diseases affecting different stages of the crop

DISEASE	STAGE	SYMPTOMS	SEASON	CAUSES
Blast	All stages of growth	Leaf lesions – grey centres large in the middle, tapering towards ends. Also attacks nodes on stem. Panicle (neck) rot is similar to stem borer effect	Mostly wet cloudy skies; frequent rain and drizzle	High nitrogen levels, High relative humidity
Sheath blight	Tillering	Leaf sheath – greyish green lesions between the water and the leaf blade	Periodic	High temperature and humidity
Bacterial leaf blight	Tillering to heading	Leaf lesions run along the length of the leaf	Wet	High temperature and humidity
Sheath rot	Boot leaf	Small water soaked lesions on leaves	Periodic	High temperature and humidity
Brown spot	Flowering to maturity	Brown round to oval spots on leaves	Periodic	25–30 °C temp and high humidity
False smut	Flowering and maturity	Ovaries transformed into large green masses	Periodic	Rainfall accompanied by cloudy days
Tungro virus	Flowering and maturity	Stunting of the plant and yellow to orange leaves	Periodic	Usage of more N and more vector activity

Rice brown leaf spot (*Helminthosporium oryzae*)

Symptoms

This is a seed-borne fungal disease. The leaves show round to oval or irregular brown spots which may coalesce to cause withering of tissues. A velvety growth may be seen on the glumes. Sometimes browning or greyish browning may be seen at the neck region. The grains show reddish brown discolouration. These spots appear like sesame seeds: hence this condition is also known as sesame leaf spot.

Management

- Seed treatment with 20% mint leaf extract for 24 hours.
- Spread the mature leaves of *Cleistanthus collinus* all over the field (25 quintals/hectare) and allow them to decay. Irrigate after three days.
- Dusting of ash checks the spread of this disease.

Sheath blight (*Rhizoctonia solani*)

Symptoms

This is a fungal disease that spreads through weeds and pathogens. The first symptom seen on the leaf sheath is the appearance of

greenish grey lesions. Later, lesions turn to straw colour and increase in size which girdles the stem. The leaf blade of the affected sheath dries up from the tip downwards. The grains are shrivelled and poorly filled.

Stem rot (*Leptosphaeria salvinii*)

Symptoms

This is a soil-borne fungal disease. The disease appears after transplanting, in the form of small, black irregular lesions at the water line on the leaf sheath and stem. Infected stem rots and breaks. Spikelets appearing in the affected plants remain chaffy. Disease is more severe in those fields where the water is found to remain stagnant and lack proper drainage facility.

Bacterial disease:

Bacterial leaf blight (*Xanthomonas campestris PV. Oryzae*)

Symptoms

This is a seed-borne bacterial disease. It is characterized by the appearance of yellow colour, water-soaked lesions on both the edges of the leaves. Later, they coalesce and the entire surface turns straw coloured. The affected leaves roll completely, droop and ultimately the tillers wither away. These symptoms usually appear 4–6 weeks after transplanting. Affected plants produce chaffy grains. Use of high nitrogenous fertilizer rates favours blight epidemics especially where susceptible cultivars are grown.

Management

A slurry is prepared by mixing 20 kg of cow dung with 200 litres of water. The mixture is strained through a gunny bag. The filtrate is further diluted with 50 litres of water and allowed to stand. The water is then decanted, strained and sprayed.

Viral diseases:

Tungro or leaf yellowing *Maize chlorotic dwarf virus*

Symptoms

This disease is spread through viral particles. Older leaves turn yellowish orange starting from the tips and spreading downwards to eventually cover the entire leaf. Young leaves are mottled with pale green to whitish spots. Root development is poor and grains are

usually covered with dark brown blotches. Plants become stunted and bear poor panicles with empty glumes. This disease is transmitted by the green leaf hopper (*Nephotettix virescens*).

General management of diseases

Take cow's urine in a mud pot and allow it to ferment for one week. Spraying this over the crops controls bacterial and fungal diseases.

Mix one litre of cow's urine with one litre of buttermilk and eight litres of water. Spraying this extract over the crop also controls bacterial and fungal disease.

Mix 300 ml of sweet flag extract with one litre of cow's urine and 8.7 litres of water. Spraying this extract controls the spread of disease.

Nutritional disorders: The growth of a crop will be abnormal when any of the essential nutrients is deficient in the soil. Nutrient deficiency in rice can be identified by certain characteristic deficiency symptoms. A few major nutrients – along with their deficiency symptoms – are listed below:

Nitrogen deficiency or excess Poor tillering and chlorosis of leaves are observed with deficiency. The intensity of the green colour depends on the intensity of nitrogen deficiency. With excess nitrogen, the plants produce bluish green leaves and become highly susceptible to pest and disease attack.

Phosphorus Phosphorous deficiency is often found in calcareous, heavy black and alkaline soils. Lower or older leaves lose their normal green colour and poor tillering is observed. Bluish green leaves are observed even when the level of nitrogen is normal.

Potassium Intensive multiple cropping with less potassium application leads to depletion of potassium. The deficiency symptoms appear on older leaves. These leaves lose their normal green colour and develop brown or yellow patches from the leaf tip extending towards the leaf

base. The midrib portion is green in colour and resembles a leaf affected by bacterial leaf blight. Potassium deficiency leads to intense pest and disease attacks and the crop lodges due to a weak stem.

Zinc

Zinc deficiency is more easily found in heavy clay, calcareous, highly alkaline soils and soils with improper drainage. Chlorosis of lower leaves and bleaching of the midrib portion is seen with the top one-third leaves remaining normal. The symptoms are noticed in young leaves and disappear at about 25 days after transplantation. Severe deficiency leads to the production of reddish brown necrotic spots which merge and extend throughout the leaf. The leaves will be small, spindle shaped, brittle and break easily.

Iron

Iron chlorosis of young leaves is common in rain fed rice and in alkaline and calcareous soils. It is also common when the crop is irrigated with water having high carbonates and when heavy doses of phosphatic fertilizers are applied. Inter-veinal chlorosis of leaves is observed and, in cases of severe deficiency, the whole leaf appears bleached. Drying starts from the tip and extends to the inner parts. The yellow leaves turn brick red, then dry and drop.

HARVESTING

The crop should be harvested when the grains are fully mature and turn yellow or straw colour (varies according to the variety). Timely harvesting ensures good grain quality and consumer acceptance, since the grain is less likely to break when milled. Harvesting should be carried out when the moisture content of the grain is about 20–25% and when about 80% of the panicles have about 80% of ripened spikelets. If delayed, grain may be lost due to damage by rats, birds, insects, shattering and lodging.

The crop is generally cut by hand using sickles with a serrated edge. The plants should be cut quite close to the ground and left in the field for a few days to dry.

Later on they should be collected in bundles and stacked for threshing.

POST HARVEST MANAGEMENT

Drying

Direct drying under the sun leads to increased breakage of the grains during milling. Gradual drying in the shade is essential for better recovery in the mills. The moisture content should be reduced to 13–14 percent before milling.

Threshing

The most common methods of threshing are trampling by bullocks, rubbing with bare human feet (in hills) or lifting the bundles and striking them on a raised wooden platform. On big farms, pedal threshers or power driven stationary threshers are also in use. Threshing of rice is still a major problem on small farms.

Milling

The produce, after harvesting, is known as rough rice, paddy or grain. The rough rice is milled before it is consumed. With the husk or hull removed, the highly milled rice is white, translucent or opaque and is classified as head rice, broken, screenings or brewers' rice, according to the size of the kernels.

STORAGE

Proper storage of the produce is necessary. If rice is stored in a moist place, fungal attack will set in and this will lead to grain discolouration. Bad odour and bitter taste may also develop. To avoid such problems, controlled mechanical drying of paddy is useful. In advanced countries, mechanical devices and large-scale storage units are available and these facilities can be availed by farmers on custom-service basis. Such a system can be adopted in our country. Alternatively, economical and effective storage structures that are available now can be established at block or district levels.

Traditional storage techniques

The *ambaram* is a traditional seed storage structure that has been in use for more than a hundred years in several villages of Tamil Nadu. It is constructed in an open space and grain stored in it for more

than a year. The straw of tall traditional paddy varieties like *samba mosanam*, *kappakar*, *kullakar* and *vaigunda* are used in making an *ambara*m.

The size of these structures is need-based. To set up an *ambaram* of eight tonnes capacity, soil is first heaped to a height of about one foot with a six feet diameter. A two-inch layer of straw is spread over this and old gunny bags spread over. Around this, three haystacks are laid, one above the other and tied intact. Two handfuls of long paddy straw are taken and tied vertically in two places. Likewise, the required amount of straw is taken and placed at the base. The paddy grain is poured into the structure to a height of about six feet. Above this, paddy straw is once again spread in a layer about 1.5 feet thick and is tied intact, again using paddy straw. The structure is finally covered using palm leaves.

Advantages

- The grain can be protected from cattle and rodents.
- The ambaram also offers protection from storage grain pests.
- Quality and viability of the seeds is maintained.
- The cost incurred on gunny bags is saved.
- The ambaram overcomes the constraints on space for storage in houses (since it is always constructed in the open space).

Storage pests

Rice weevil (*Sitophilus oryzae*)

Life cycle

Adults are reddish brown or black in colour. They have four light, reddish or yellowish spots on the elytra. The adult lays about 200 eggs inside the grain kernel. The eggs are oval, whitish and transparent. Tiny whitish grubs emerge from these eggs in 3–6 days. The grubs are yellowish brown headed. The larval stage lasts for about 19–34 days. They enter the pupation stage inside the grain. Pupal period lasts for 3–6 days. The insect can complete five generations in a single year.

Damage pattern

The larvae generally feed on the endosperm of the grain, reducing its weight and food value. They generally render the grains unfit for consumption. Moreover, the larvae also produce large quantities of powdery excreta. This generates an unpleasant odour in addition to contaminating the grain with dust particles.

Lesser grain borer (*Rhizopertha dominica*)

Life cycle

Adults are tiny, shiny, dark brown or black in colour. The wings are highly active. The head is bent under the thorax. Adult female lies about 300–500 eggs among the grains. The egg stage lasts for 5–11 days. The larvae that emerge from the eggs are white coloured and brown headed. The larval stage lasts for 24–50 days. They undergo pupation on the surface of the grain, which lasts for 7–8 days. The insect completes about 3–4 generations in a year.

Damage pattern

The larvae bore holes into the food grains and eat away the flour. Both larvae and adult feed voraciously and can cause serious damage.

Angoumois grain moth (*Sitotroga cerealella*)

Life cycle

Adults lay about 400 eggs on the surface of the grains. They lay eggs on the panicles and on the grains. The eggs are initially whitish and gradually turn reddish. The eggs are oval in shape. The larvae emerge from these eggs in about a week. The larval stage lasts for 7–14 days. They enter into pupation when among the grains. The adults emerge from the pupa in 4–6 days. The adults are yellowish brown in colour with tiny sharp wings.

Damage pattern

The infestation begins at the field level. In the storage godowns, the pest attack is found on the upper surface of the grains. The larvae bore into the grain and remain inside until they turn into adults. As

a result of the insect attack, the grains become powdery. Larval excreta can be found along with the grain and infested grains appear grouped.

Rice moth (*Corcyra cephalonica*)

Life cycle

The adults are greyish brown in colour. Their wings measure about 14–24 mm in length. The adults lay 90–200 white coloured eggs which last for 3–5 days. The larvae that emerge from these eggs are white in colour. The larvae group the grains with their excreta, remain inside them and feed on them. The larval and pupal stages last for 20–30 days and 8–10 days respectively. They turn into pupae when among the grains.

Damage pattern

The infested grains are found grouped.

Storage pest management

- While filling grain in storage bags, place 200 gm of salt for every 50 kg of grain. This helps to control moth and weevil infestation during storage.
- Place red chilies in storage bags (@10–15 fruits per every one quintal bag). The pests stay away due to the pungent odour.
- Mix turmeric powder with paddy to protect the grain from weevils.
- Mix leaves of Ipomoea carnea along with the grain to prevent common storage pests.
- Place about 1–2 garlic bulbs in 5–10 kg of rice in the bin for storage.

Pest management in storage godowns

- Storage godowns should be kept clean. Wastes and other unwanted materials in the godown area should be periodically removed.
- Cracks found on the floor, walls and roof should be sealed.
- The grain stored should not have more than 12% moisture content.

- Fumigating the storage room with frankincense powder helps to control the spread of disease causing pathogens.
- The gunny bags should be stacked with proper aeration between them so that they can be managed properly.
- If the grain is to be stored in the gunny bags for long periods, the bags should be dried first in the sun once every three months. This prevents pest attacks.
- When the grain is stored in gunny bags, they should not be kept directly on the floor but on wooden logs that are one foot above the ground level. By this method, the grains can be protected from getting moist and pest attack can be controlled.
- When the grains are stored in mud pots, the mouth of the pot should be sealed with neem leaf paste to prevent entry of pests.
- Pest attack during storage can be avoided by mixing the seed with neem oil. One kilo of paddy seeds should be mixed with 10 ml of neem oil and dried in the shade before it is stored.
- Gunny bags used for seed storage should be treated with 10% neem seed kernel extract before being used. (The extract should be used immediately after preparation.) They should be soaked in the extract for 15 minutes, then dried in the shade before they are used for storing grains. In case the gunny bags are new, they should be soaked for half an hour. If the gunny bags are with a close mesh and small pores, a thinner solution should be prepared. By using this method, grain can be protected from insects for about four months.
- In store rooms, along with the cow dung that is used for cleaning the mud floor, neem seed kernel extract or neem oil should be used directly (in the same concentration used for spraying purposes).

- The same could also be used for mud walls.
- If bamboo bins are used for storage, the bins can be painted with thick neem seed kernel extract. This prevents the pests from getting into the bin.
- The seeds and grains stored in the godowns can be protected from pests by placing the leaves of *vitex*, neem and pongam on the gunny bags and in different places of the godown.
- While filling the gunny bags, for every 20 kg of seeds, two handfuls of the powder of *vitex*, neem and pongam leaves should be spread. By using this method, grain can be protected from insects for more than a year.
- Storage godowns or rooms should have proper aeration.
- Adult moths can be controlled by fumigation with neem or *vitex* leaves.

System of rice intensification (SRI)

The System of Rice Intensification (SRI) is a method of rice cultivation adopted from Madagascar. It requires a very low seed rate (5–6 kg/ ha) i.e., only 10–20 % of existing seed rates (50–60 kg/ ha) and less water. It is peculiar in that –

Seedlings are transplanted at the two leaf stage, i.e., when only 10–15 days old.

Seedlings are planted singly rather than in clumps (two or more).

Spacing is wider: 25 x 25 cm

About 3 cm water is retained in the field during flowering but is drained 20 days before harvesting is to begin.

Organic inputs: vermicompost @ 1000 kg/ha during transplantation.

Transplanting and cultivation method

To maintain spacing and to guide the person transplanting, use a PVC pipe marker.

After one month, do weeding and apply a dose of *sanjeevani* mixture (10 kg cow dung and 10 litre cow urine, fermented for four days).

One month after the first weeding, a second weeding is done and another dose of *sanjeevani* mixture is applied. Moist but unflooded condition of soil is maintained by applying water and draining excess water.

On an average, 25–30 tillers per seedling are observed.

Three vermiwash sprayings are done as per the schedule below:

1st: 10% vermiwash – 15 days after transplanting

2nd: 10% vermiwash – 20 days after the first spray

3rd: 5% vermiwash – during flowering stage

Benefits of SRI

- Seed rate is extremely low (when compared with conventional practice): 10–20 %
- Water requirement is much less as well, i.e., 35–40% of present practices.
- No chemical fertilizers are required – only organic compost and vermicompost need to be used to get better yields. Cost of production decreases by about 30–40 %.
- Local varieties can be used which saves on seed purchase cost and reduces risk of pest attacks.
- Mortality of plants is very low (5%).
- Each seedling gives out about 16–22 panicles.

ORGANIC RICE CULTIVATION

Case studies

The Kappakar paddy variety is usually cultivated in clayey soil as a dry sown crop during the *samba* season. More than thirty farmers have been conserving seeds of this variety in Thiruvanaikovil village of Thirukazhukundram block for more than three generations. The variety can tolerate drought as well as withstand floods. The rice of this variety is ideal for making *idli* and *dosa*. It also tastes good if the cooked rice is left overnight and then consumed. The hay of this paddy variety is also a good fodder for the cows. During the *samba* season of 2002, a few farmers had sown Kappakar and some had sown a high yielding variety called white Ponni (as a dry sown crop). Since there was no rain for two months subsequent to sowing, the crops withered. However, as soon as it rained, the Kappakar crop recovered and turned green. On the other hand, the Ponni crop did not recover at all. The average yield from Kappakar was about 40–42 bags per hectare.

Source: Mr. S. Varadharajan, Mr. Sankar, Mr. Krishnan, Mr. Manickam, Thiruvanaikovil, Ozhalur (P.O.), Thirukazhukundram block, Kancheepuram district.

Sambamosanam for water logged areas

A. Palanivel is a farmer who hails from the Arasankudi village of Trichy district. A part of his land is very close to the irrigation canal and there is water seepage on his land continuously. The soil type is a mixture of alluvium and clay. In the rainy season, the field looks almost like a pond due to water logging. Mr. Palanivel approached CIKS for seeds of *Sambamosanam* as it can withstand water logging. Except for a period of 12–15 days, there was water logging throughout the duration of the crop. Inspite of this, Palanivel obtained a yield of 2,280 kg of paddy from 70 cents of land. His total income from paddy and fodder was Rs.13,710 and his expenditure, Rs.3,050. His net income was Rs.10,660.

Source: Mr. A. Palanivel, Arasangudi village, Tiruvarambur (via, taluk), Trichy.

GROUNDNUT

Tamil – *nelakadalai, verkadalai*

BACKGROUND TO THE CROP

Groundnut (*Arachis hypogaea)* is also known as peanut and earthnut. *Arachis* means a 'legume' and *hypogaea* means 'below ground' (referring to the formation of pods in the soil). Groundnut is one of the major oil seeds of the world. In India, it has the largest share among the oil seeds with regard to area and production.

Area and production

Groundnut occupies an area of 24.7 million hectares around the world with a total production of 33 million tonnes. Of this, 13 million hectares are in Asia, mostly in India (about 8 million hectares) and China (about 4 million hectares). The rest of the cultivation is in sub-Saharan Africa (9 million hectares) and in North and Central America (0.7 million hectares). India occupies the first place with regard to acreage but stands second in production. Gujarat, Andhra Pradesh, Tamil Nadu and Karnataka contribute about 70% of the area and account for 75% of the total production.

Climate

Groundnut is a tropical plant that requires a long, warm growing season. It can grow up to an elevation of 1160 m above sea level. A well-distributed rainfall of at least 50 cm during growing season, abundant sunshine and relatively warm temperatures are best suited for its cultivation. Temperatures between 21–26 °C are ideal for its growth and development. During the ripening stage, the plant requires about a month of warm and dry weather. Temperatures below 20 °C retard its development while those above 35 °C will adversely affect its flowering. Lower temperatures initially retard, and then prevent, growth: the plant is generally killed by frost at any stage

Growing season

Kharif (rainy/monsoon) – About 85% of groundnut grown in India is sown in the *kharif* season under rain-fed conditions. The time of sowing varies from June to November depending on the type of soil and rainfall.

Rabi (post rainy/winter) – About 10% of the crop is raised during the *rabi* season. The crop is usually grown in rice fallows from October–March.

Summer season: In areas where irrigation is available or assured, the summer is ideal for groundnut cultivation. Good sunshine and high temperature favour pod formation.

Intercrops and crop rotation

Groundnut is usually grown as a mixed crop with pearl millet, maize, sorghum, castor and cotton. As a *kharif* crop, it is grown year after year. During the *kharif* season, it is a common practice among farmers to sow two lines of maize after every four lines of groundnut. Maize matures early and is hence harvested early. The furrows made after the maize is harvested are used to collect the rain water which is sprinkled on the adjoining four lines of groundnut. This practice facilitates easy harvesting.

In certain districts of Tamil Nadu, cowpea is intercropped with groundnut. Cowpea, being more succulent, attracts sucking pests and thereby reduces the damage to the groundnut crop. In certain places, groundnut is grown in rotation with wheat, jowar, bajra and garden crops such as chickpea, onions, chilies, garlic, ginger and turmeric. Groundnut fixes nitrogen in the soil. Hence the crop that is grown next to it will show a 25% increase in yield. More vegetative growth is observed in groundnut grown after cumin. In Andhra Pradesh and Maharashtra, sorghum is grown next to groundnut. When groundnut is sown as an irrigated crop, during the months of November and December, gingelly, Bengal gram and cowpea can be grown on the bunds. After 45 days, when weeding is done, cotton can be planted and gypsum applied to the field.

Within three months, the groundnut can be harvested along with the oil seeds and pulses. Cotton can be picked later. This practice reduces the costs of ploughing, formation of ridges and furrows, weeding and spraying. Moreover, farmers can take advantage of three harvests in a single season.

Soil

Groundnut is grown on a wide variety of soil types. However, a well-drained, light, loose, friable, sandy loam, well supplied with calcium and a moderate amount of organic matter, is ideal for its cultivation. A well-drained soil facilitates adequate exchanges of air to meet the nitrogen, carbon dioxide and oxygen requirements of the crop.

When oxygen supply to the soil is poor, root growth is impeded and metabolic functions retarded. In the absence of adequate oxygen in the root zone, the nitrogen-fixing bacteria are also ineffective and the roots are unable to take up soil nitrogen.

In loose, friable, sandy loams, germination of seeds and emergence of seedlings is better. Such soils facilitate easy penetration of the pegs and their development and make harvesting easy. Adequate calcium is essential in soils for the production of pods with sound matured kernels. A moderate amount of organic matter (less than 2%) increases the water and nutrient holding capacity of the soil. Again, good yields are possible in soils with a pH between 6.0–6.5.

More than fertility, the texture of the soil is very important. Fine textured soils, heavy and stiff clays are avoided for the rain-fed crop as they cause difficulties in harvesting. Alkaline soils are undesirable.

Crop duration

The duration of the crop is 90–105 days for bunch types and between 120–130 days for spreading and semi-spreading types.

VARIETIES

Groundnut breeding in India reached a sort of watershed in the eighties when 30 new varieties were released. Of the new cultivars, 80% were cross derivatives. During the period, stress was laid on resistance breeding. As a result, foliar disease resistance varieties like Girnar 1, ICGS 10 and ICGU 86590 were released. In groundnut, the varieties under cultivation fall under three botanical groups, viz., Spanish, Valencia and Virginia. The popular ones include JL 24, VR 1, VRI 2, VRI3, TMV2, TMV7, CO2 and BSR-1.

SEED

Selection

Mixed seed can lower the market value of the crop. Hence, the source from which the seed is obtained is critical. Good quality seeds are pure, with high germination capacity, uniform seed size, colour and weight, besides being free from seed-borne diseases. The seed viability determines the germination capacity, the stand of the crop and its ultimate yield.

Seeds of bunch types (Spanish and Valencia) are non-dormant and hence germinate immediately after maturity. Seeds of semi-spreading (Virginia bunch) and spreading varieties (Virginia runner) are dormant and undergo a resting period of between 60 to 75 days before germination. Storing such seed along with ripening bananas for three to four days in air-tight containers will help in breaking dormancy. Seed germination in bunch types should be from 90 to 95% and in spreading types, from 85 to 90%. Germination less than 85% is not considered satisfactory.

Seeds retain their viability for longer periods if kept unshelled. The pods should be shelled by hand one week prior to sowing. Hand shelling reduces damage to seeds. Wherever hand shelling is not possible (due to scarcity of labour), groundnut decorticators can be used for shelling the pods.

When pods are shelled long before sowing, they are liable to suffer from loss of viability rapidly and damage due to pests, etc.

Small, shrivelled and diseased kernels should be discarded and only bold seeds should be used for purposes of seed.

Seed rate

The seed rate is an important criterion for an optimum plant population in the field and to achieve good yields. It depends on the variety cultivated. Semi-spreading and spreading varieties require 110 kg/ha while bunch varieties require 120 kg/ha.

Treatment

Before sowing, the seeds can be smeared with lime solution. The heat produced by the lime solution enhances germination.

Seed treatment with asafoetida solution helps to protect the crop from blight. Asafoetida solution is prepared by mixing 250 gm of asafoetida in two litres of water. This quantity is sufficient for treating twenty kilo of seeds. The seeds should be soaked in this solution for twelve hours before sowing.

Inoculation of seed with efficient strains of nitrogen-fixing bacteria is necessary for areas where groundnut is not generally grown. Seed inoculation with three packets (600 gm) of *rhizobium* per hectare is recommended.

Bio-control agents like *Trichoderma viride* @ 4 gm/kg of seed or *Pseudomonas fluorescens* @10 gm/kg of seed can also be used for seed treatment.

In addition, groundnut seed can also be treated with *amrut pani/panchagavya/cow pat pit* or *jeevamrut*.

CULTIVATION

Main field preparation

The soil should be very well prepared to provide an ideal seedbed. Such soil preparation also helps to control weeds, facilitates infiltration of rains and ensures that insect pupae and fungi are destroyed by exposing them to the hot sun. Adequate supply of moisture, oxygen, optimum soil temperature and freedom from mechanical impediments are the basic requirements for seed germination, seedling emergence and root growth.

Soil preparation for rain-fed groundnut depends on rainfall and soil type. For *kharif* groundnut, the land should be prepared thoroughly after the receipt of summer showers. This will help in sowing the crop early in the season, well before the onset of the monsoon. Ploughing should not be done when the soil is wet. Ploughing of wet soil leads to a cloddy seedbed, resulting in poor germination of seeds and a low plant population. The field should be carved into beds that will suit the border strip method of irrigation. This facilitates sowing with a seed drill and also prevents the loss of land in bunds as happens in the check basin method.

After the onset of rains, the soil is pulverized by providing two ploughings to get a good tilth. The third and final ploughing is done just before the sowing. In irrigated areas, depending upon the source of irrigation, beds of convenient size are made and sufficient ploughing is done to obtain a good tilth.

In certain areas, farmers plough their groundnut fields immediately after the monsoon crop and keep the furrows exposed till the onset of the next monsoon. They believe that the fine soil and dust deposited in the furrows by the wind during summer will benefit the groundnut that will be planted in the following season in the same furrows.

Sowing

In the case of a rain-fed crop, sowing should be undertaken immediately with the advent of the monsoon (last week of June or first week of July) and should be completed as early as possible. Delayed sowing may result in reduction in yields. In cases where irrigation facilities are available, sowing should be undertaken 10–12 days before the onset of the monsoon with a pre-sowing watering. This helps the crop to make the best use of the monsoon showers and results in higher yields. For the *rabi* crop, sowing should be taken up in the months of November–December.

Method of sowing

The seeds are dibbled either manually or mechanically (using a seed drill) to a depth of 7.5–10 cm.

Spacing

The spacing adopted differs according to the variety and from place to place.

Bunch types: 20–30 x 10–20 cm

Spreading types: 45–60 x 20 cm

In the Saurashtra region of Gujarat, farmers have the habit of planting groundnut year after year in the same furrow. They adopt a spacing of 90 cm between the rows for the spreading varieties. This traditional practice of sowing is best suited to the local ecological conditions and to available natural resources.

Interculture

Inter cultivation operations have to be started as soon as the rows of groundnut seedlings are visible, and repeated at regular intervals till 45 days after sowing or until the plants occupy a greater portion of the land. Shallow intercultivation is adequate.

Weeds

Cultural practices such as the method of sowing (broad bed/furrow system), plant density (optimum plant population of 33 plants/m^2), crop varieties (spreading/semi-spreading varieties/bunch varieties), doses and methods of nutrient management and methods of irrigation, all have a pronounced effect on crop-weed interference.

Weeds reduce the yield considerably. In groundnut, 20–45% yield reduction has been recorded due to weed problems. Depending on the soil type and the extent of weed infestation, two hand hoeings and weedings should be done. The first hoeing should be done three weeks after sowing. This should be repeated in the second and third weeks thereafter before the onset of flowering. Generally, hand weeding is practised in groundnut. The first weeding is done 25 days after sowing and it is repeated once later.

Weeding should not be done later than 45 days as it may interrupt peg elongation and pod formation.

Earthing up

Earthing up should be taken up simultaneously with intercultural operations (40 days). It facilitates maximum penetration of pegs and provides a larger spreading area. Apply gypsum @ 500 kg/ha during earthing up to facilitate peg penetration and to obtain good oil content.

WATER REQUIREMENTS

Depending on the soil texture, the frequency of irrigation will vary. However, irrigation must be given during the critical stages of growth like flowering, peg formation and pod development. In areas that receive 50–70 cm of rainfall, 2–3 irrigations should be given. For the *rabi* crop, 3–4 irrigations are necessary. In case of limited water availability, single irrigation at the time of flowering is compulsory. Irrigation of the plot just before harvesting will make the operation easier.

MANAGING SOIL FERTILITY

Groundnut is a deep-rooted plant and hence uses both moisture and nutrients from the deeper layers of the soil. Nitrogen requirement in the rain-fed crop is 10–20 kg/ha and in the irrigated crop, 20–40 kg/ha. Phosphorus requirement for the rain-fed crop is 20 to 40 kg/ha and in the irrigated crop, 40 to 90 kg/ha. Although Indian soils are rich in potassium, the recommended dose is 20 to 40 kg/ha both for the rain-fed and the irrigated crop. The application of gypsum at the rate of 500 kg/ha at pegging stage will enhance pod fixation. In virgin lands, when groundnut is newly introduced, the application of a culture of *rhizobium* as seed treatment is beneficial for increasing nodulation and nitrogen fixation.

Spraying buttermilk 25 and 35 days after sowing fetches good yields. It serves as a growth promoter. Three litres of buttermilk prepared by diluting ½ litre of curd is sprayed over the crop.

Organic manures

Farmyard manure (FYM) and compost are the main organic sources of nutrients for groundnut. Organic matter improves soil structure and reduces compaction and crusting of the soil. It is also required as a source of energy for nodulation and nitrogen fixation by microorganisms. A hard soil may affect pod formation. Adding FYM @ 12.5 tonnes/ha or 4–5 tonnes NADEP/BD/vermicompost helps to get rid of such problems. FYM improves the porosity and structure of the soil and supplies the crop with the required micronutrients. It also helps to get rid of harmful microorganisms in the soil. Besides cow dung, FYM also contains stubbles, stalks and other crop residues. These should be applied well in advance, i.e., 15–30 days before sowing and incorporated into the soil with the help of a country plough or a blade harrow. For a rain-fed crop, 6–7 tonnes and for an irrigated crop, 12–13 tonnes of farmyard manure should be added. An alternative to FYM is to practise green manuring with crops like sunhemp, daincha and other legumes.

Green manuring with sunhemp/sesbania/cowpea can also be attempted.

Besides these, soil enrichment through bio enhancers, viz., cow pat pit/BD 500/*amrut pani*/*jeevamrut*/*panchagavya* is also advised.

Two to three foliar sprays of BD 501, *panchagavya* or soil application of *amrut pani* through irrigation water will promote vigour and improve productivity.

PROBLEM INSECTS

Root and pod feeders:

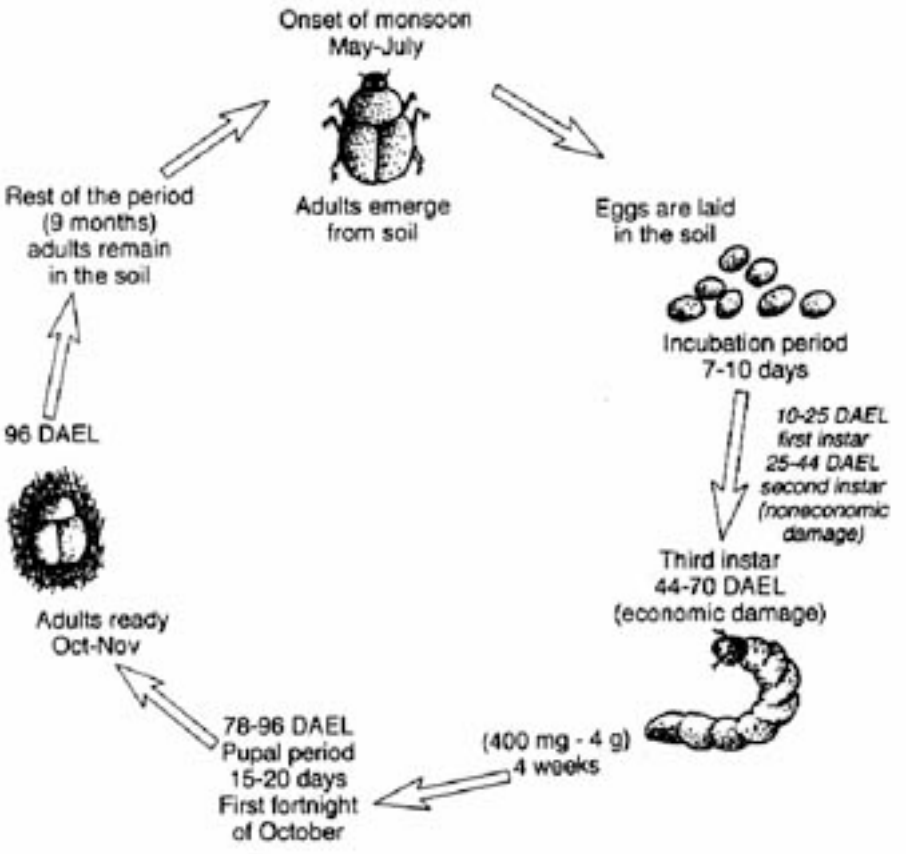
White grubs (*Lachnosterna consanguinea, L. reynaudi, and L. serrata*)

White grubs are serious pests of groundnut in north and north-east Gujarat, Rajasthan, Punjab, Haryana and Uttar Pradesh. In the southern states, their presence is restricted to sandy soils. They are polyphagous in nature.

Life cycle

The adults emerge from the pupae and hibernate in the soil till the following season. The adult beetles are 18–20 mm long and 7–9 mm wide. The fully grown grubs are stout with strong mandibles.

The head is yellowish and the body is 'C' shaped. They have three pairs of thoracic legs. The wrinkled portions of the body are dirty white in colour and the posterior smooth portion is brownish in colour. Egg laying begins after the summer rains. The eggs are laid singly at a depth of 5–8 cm. A single female lays 20–80 eggs. The eggs are pearl-white and oval. The eggs hatch in 9–11 days. The grubs, which hatch out of the eggs, are white, translucent and 5 mm long and they have three instars. The grubs feed on the organic matter for a few weeks and then feed on the fine rootlets and pods. Pupation takes place in the soil where the insects remain as pupae until the following year. Mating takes place at the feeding sites. After feeding, the adults reenter the soil to hide and lay their eggs. After the monsoon rains, the adults emerge from the soil. The adults are 18–20 mm long and 7–9 mm wide across the thorax.



Life cycle of white grubs

Damage pattern

The grubs attack starts in the crop about one month after the mass emergence of beetles, i.e., after the first pre-monsoon or monsoon rain. The damage usually occurs in patches in the field. Grubs feed on the fine rootlets and nodules. This results in wilting and death.

Management

- Summer ploughing helps to bring out the larvae and pupae from the soil. Predatory birds can then feed on them.
- Seed treatment should be done with Solanum surattense extract.
- Early sowing helps the plants to escape from grub damage.
- Setting up light traps helps to monitor and collect the adult beetles.
- The adults can be manually picked from the soil and destroyed.
- Treat the kernels with kerosene (one litre per 70–80 kg seeds) before sowing.

Termites (*Odontotermes sp.*)

Termites are polyphagous in nature. They are distributed in all groundnut growing areas in India. Termite infestation is severe in sandy and sandy loam soils.

Life cycle

Termites are social insects that live in termitaria in distinct castes like workers, kings and queens. The queen lives for several years and lays several 1000 eggs during its lifetime.

Damage pattern

The insects remain underground and feed on the roots. They penetrate and hollow out the tap root and cause wilting. This results in premature death of the plants. They bore into pods, damage the seeds and weaken the shells.

Management

- Harvesting the groundnut immediately after it matures and early removal of produce from the field reduces termite attack.
- Twigs of morning glory (Ipomoea fistulosa) can be used for the protection of pods from termites.

Earwig (*Anisolabis stali*)

The earwig is a main pest in south India, particularly in clayey soils. It also infests cabbage, cotton bolls and sorghum stems.

Life cycle (56–72 days)

Eggs are pearl white in colour and lie in clusters. The nymphs and adults look similar except for the forked abdominal tip in the nymphs. The females lay between 21–108 eggs. The eggs hatch in about a week. Nymphs pass through five instars.

Damage pattern

Both nymphs and adults bore into the pod and feed on the seeds. Infested pods are prone to fungal attack.

Groundnut bruchid (*Caryedon serratus*)

This pest is found in Andhra Pradesh, Gujarat, Karnataka, Maharashtra and Tamil Nadu.

Life cycle

The adult beetles are brown in colour, measuring 4–7 mm long and 5 mm wide. They have a large hind leg. The eggs are translucent milky white in colour and are found attached to the pod walls.

Damage pattern

After hatching, the larva directly burrows into the pod wall and eats away the seeds. The first sign of attack is the appearance of 'windows' cut into the pod wall by the larva. After emerging from the pupal cocoon, the adults escape from the pod through these window cuts. When the infested pods are opened, silk and excreta can be seen on the seeds. The pupae are often found in large numbers at the bottom of the pile of sacks.

The infested seed is unfit for human consumption or for oil expulsion.

Jewel beetle (*Sphenoptera indica*)

The beetle is most common in south India during the rainy – and post rainy – season.

Life cycle

Adult beetles are shiny and dark brown in colour, measuring about 10 mm in length. The grubs are whitish with a globular head and with an elongated, dorsoventrally flattened body. They are also legless. The grubs grow up to 2.5 cm. The eggs are laid singly on the main stem.

Damage pattern

On hatching, the grubs burrow into the stem and tunnel into the roots causing the plant to wilt and die. When the infested plant is pulled out, grubs and pupae can be seen in its hollowed stem.

Sucking pests:

Jassids (*Empoasca kerri*)

E. kerri is most common in Maharashtra, Gujarat and Tamilnadu. The pest outbreak is severe during August–September and February–March.

Life cycle

The adults are yellowish green with a flat vertex. The wings are long, narrow, semi-transparent and pale green in colour. The distal ends of the wings are slightly grayish. The nymphs are like adults but they are wingless. The eggs of the jassids are inserted into the leaf tissue close to the midrib. The eggs hatch out in about a week. Each female produces about 40 nymphs. The nymphs develop into adults in ten days.

Damage pattern

Both the nymphs and adults cause damage by sucking the sap from the central surface of the young leaves. As they suck, they inject toxins into the plant issue. This results in a whitening of the leaves and formation of 'V' shaped chlorotic patches at the tip of each

leaflet. As the infestation gets more severe, the crop turns yellow and presents a scorched appearance known as 'hopper burn'.

Economic threshold level

Management measures should be implemented immediately if more than 10% of the leaves show characteristic 'hopper burn' symptoms.

Management

- Intercropping groundnut with lablab in a 4 : 1 ratio reduces the number of jassids on groundnut.
- Spray 1% neem leaf solution per hectare.

Thrips (*Scirtothrips dorsalis, Thrips palmi, Frankliniella schutzei, Caliothrips indicus*)

Thrips are polyphagous pests, soft-bodied, having highly fringed wings. They remain mostly in folded leaflets and flowers. Hence they are hardly noticed.

Life cycle

Thrips are 2 mm long and pale green in colour. The adults lay about 40–50 eggs which are inserted into the plant tissues. The nymphs pass through four instars before transforming into adults, a period which takes about fifteen days. The adults live for twenty days.

Damage pattern

The nymphs and adults lacerate the leaf surface and suck the oozing sap. This results in distortion of the leaflets and formation of white patches on their upper surfaces and necrotic patches on the lower. When the infestation gets severe, the plant remains stunted. Thrips transmit peanut bud necrosis.

Economic threshold level

Management measures should be implemented when five thrips are found per terminal leaf in a 30 day old crop.

Management

- Thrips damage can be avoided by early (first fortnight of June) sowing.
- Intercropping with sunflower reduces the thrips population.

Aphids (*Aphis craccivora*)

Aphids are cosmopolitan in distribution and at times cause severe infestation. They remain active throughout the year and peak incidence occurs during drought periods. Infestation by these insects is relatively higher in the *rabi* crop. They also occur in crops such as red gram, bengal gram, soybean, lucerne, black gram, green gram, peas and sesbania.

Life cycle

Aphids are small sized insects measuring 2 mm in length. They are pear shaped, greenish or greenish black in colour. The nymphs are dark brown and they turn into shiny black adults in about 10 days. *Aphis craccivora* reproduces without mating. The female adult occurs both in alate and apterous forms. The nymphs pass through four moults before they become adults. Each instar lasts for 1–2 days. Each female gives birth to 15–20 young ones. They mature in a week's time. Hence multiplication is faster.

Damage pattern

Both the nymphs and adults suck the sap from the tender growing shoots and flowers. This results in distortion of the foliage and stems. Sooty moulds develop on their honey dew secretion. They transmit peanut stripe virus and the groundnut rosette virus complex.

- Release of parasites and predators such as coccinellids helps to control aphid populations.
- Release of aphid lion, *Chrysoperla carnea* grubs @ 3000/ha.

Red spider mite (*Tetranychus cinnabarinus*)

Red spider mites are minor pests of groundnut in India. The damage is severe in crops that grow under drought stress.

Life cycle

The adults lay eggs on the under surface of the leaves. The eggs hatch in 3–5 days. The life cycle is completed in 15 days.

Damage pattern

Nymphs and adults suck the sap from the under surface of the leaves. The infested leaves show yellowing and finally turn white. Fine webbings appear on the under surface of the leaves. The tips of the plants appear reddish due to the presence of a large number of mites. Ultimately the whole plant withers and dies. The infestation appears in patches and slowly spreads to the unaffected crop.

Dissemination of mites is mainly through human disturbance and wind.

Defoliators:

Red hairy caterpillar (*Amsacta albistriga, A. moorei*)

There are two species of red-headed hairy caterpillars. *A. moorei* is dominant in northern states while *Amsacta albistriga* is the most dangerous pest of groundnut in south India. It is very destructive. Besides groundnut, it also attacks chickpea, sorghum, cotton, castor and maize.

Life cycle

The adult moths are brownish white in colour with distinct orange bands on the abdomen. Both the forewings and hind wings are whitish in colour. The forewings have brownish streaks all over and an orange line along the margin. Distinct black spots can be seen on the hind wings. The adult moths emerge from the soil immediately after the monsoon rain. Each female lays about 700–1000 eggs in clusters in 2–6 days. They lay the eggs on the under surface of the leaves. The egg clusters are also found on soil clods and on dry leaves and twigs. The eggs are yellowish and shiny and hatch in 2–3 days. The larvae remain in clusters on the under surface of the leaves and feed on the chlorophyll content of the leaves. The young larvae are brownish and without hair. In about 40–50 days they turn into matured larvae. Mature larvae are highly active and destructive. They are reddish brown in colour and have dense hair all over the body.

These larvae burrow into the soil and remain as pupae for about 10–12 months to emerge again when the next monsoon showers arrive.

Damage pattern

The larvae eat away the leaves leaving behind the midrib, the veins and the petiole. The infested leaves appear as if grazed by cattle. They move in clusters from one field to the other and cause infestation. The yield obtained from the infested crop is considerably reduced.

Economic threshold level

The ETL for red-headed hairy caterpillar is eight egg masses per 100 m of crop length or 10% leaf damage.

Management

- Nuclear polyhedrosis virus (NPV) spray is effective in controlling the larvae when they are young.
- Egg parasitoids – *Telenomous manolus* is effective in destroying the eggs.
- Fungal parasitoids – *Aspergillus flavus* effectively controls the larvae.
- Lighting a fire near the field during the night-time helps to get rid of red hairy caterpillars as well.
- Adopt summer ploughing.
- In certain places, farmers chase away the caterpillars from the field by blowing a *sangu* (conch). Farmers start blowing the sangu from the three corners of the field. It is believed that the caterpillars congregate and try to escape through the fourth corner where they can be collected manually and destroyed.
- In rain-fed groundnut, raise one row of cowpea for every five rows of groundnut. Crops such as pigeon pea, black gram, sunflower, sesame, pearl millet or other pulses are

intercropped with groundnut. Mix lemon (150 ml) and tamarind juice (150 ml) in 15 litres of water. Apply this solution thrice for effective control.

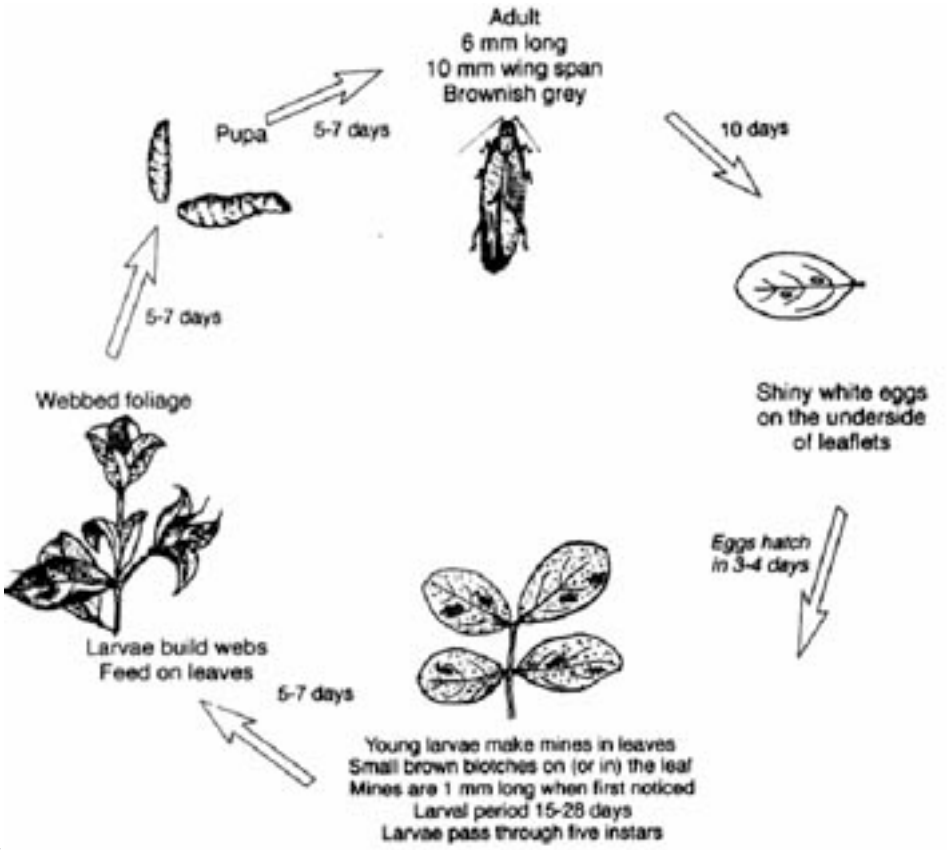
Summer ploughing

Groundnut leaf miner (*Aproaerema modicella*)

This pest is found especially in south India. Besides cotton, it also infests soybean and legumes.

Life cycle

The adult moth is brownish grey in colour, measuring 6 mm in length. The wings are highly fringed. The young larvae are shiny, black headed and greenish in colour measuring about 5–6 mm in length. The female adult lays eggs singly on the leaf surface close to the midrib. Each female lays about 200 eggs. In 3–4 days, young larvae hatch out of the eggs. In two weeks, the larvae mature and turn greenish. They remain inside the leaf folds and turn into pupae. The pupal stage lasts for 4–5 days. The adult moths which emerge from these pupae are small and blackish in colour. A prominent white spot is found on the forewings.



Life cycle of leaf miner

Damage pattern

The young larvae which hatch out of the eggs bore into the leaflets and feed on the mesophyll tissue of the leaves. As a result, small, brown blotches appear on the leaves. At later stages, the larvae web the leaflets together, remain inside the web and continue to feed on the leaf tissues. When the infestation gets severe, the leaves lose their shape and the plant remains stunted. A severely attacked crop presents a burnt appearance.

Economic threshold level

Management measures should be implemented immediately when the insect crosses the economic threshold level of one larva per metre.

Management

- In rain-fed groundnut, early sowing reduces pest incidence.
- Light traps can be set up to monitor and trap the adults.

- Pheromone traps can be set up in the field as well.
- Groundnut can be intercropped with soybean, pearl millet or lablab in 1 : 4 ratios.
- Mulching in dry lands helps to reduce leaf miner incidence.
- Spray neem seed kernel extract (15 kg/ha) or neem oil (15 litres /ha) or neem leaf extract (25 kg/ha).
- The field is first flooded to submerge the crop overnight and drained the following morning. This is a common practice among the farmers of the Tungabhadra area of Karnataka.

Tobacco caterpillar (*Spodoptera litura*)

Tobacco caterpillar infestation is severe in the fields of Karnataka, coastal areas of Andhra Pradesh and Tamil Nadu. The activity occurs during the post rainy season.

Life cycle

The young larva is light green in colour. The later instars are dark with a prominent black spot on the thorax. The fully-grown caterpillars are stout, velvety, cylindrical and pale greenish brown in colour. They have a lateral series of spots, which are purplish black in colour. The yellow coloured sub marginal series of spots have black lunules above them. The adults are stout and medium sized moths. The forewings are greyish brown in colour with wavy white markings. The hind wings are opalescent and semi-hyaline white in colour with a dark brown marginal line. Each female adult lays several hundreds of eggs in clusters on the upper surface of the leaves which are covered by brownish yellow hairs. In 2–3 days, the eggs hatch and the larvae disperse quickly. Initially light green in colour, the larvae turn dark on maturity. They pupate in the soil. The pupae are reddish brown in colour and are found close to the plants.

Damage pattern

The newly hatched larvae feed gregariously on the chlorophyll tissue of the leaves. Scratch marks can be seen on the infested parts of the leaves. At later stages, the larvae hide on the under surface of the leaves and feed on the leaf tissues at night. At times the infestation is so severe that only the petioles and branches are left behind. After infestation, the larvae migrate in groups from one plant to another.

Economic threshold level

The ETL for the pest is eight egg masses per every 100 m of crop length or 10% leaf damage.

Management

- Set up a light or pheromone trap @ 5 per acre
- Castor should be grown as a trap crop along with groundnut.
- The egg masses should be collected manually and destroyed.
- Digging trenches around the infested fields prevents the migration of larvae.
- Application of nuclear polyhedrosis virus (NPV) @ 250 LE/ha with crude sugar 2.5 kg/ha in the evening hours is effective.

Gram caterpillar (*Helicoverpa armigera*)

The gram caterpillar is a polyphagous pest distributed throughout India. The infestation is high in south India.

Life cycle

The eggs are yellowish white in colour. The caterpillars are of varied colours, mostly dark greenish brown or apple green. They have whitish or dark grey longitudinal lines with white stripes on the lateral side. The adult moths are medium sized, stout and pale brownish in colour. The forewings are pale brown in colour. They have indistinct wavy lines along the margin with a dark brown spot in the centre. The hind wings are smoky white in colour with a

blackish outer border. The pest completes about four generations in a year. Eggs are yellowish-white in colour and dome-shaped and are laid in leaf buds of groundnut and hatch in 2–5 days. The larvae pass through six instar stages. When the larvae are fully grown, they burrow into the soil to a depth of 2–18 cm for pupation. The pupae are smooth, 14–18 mm long. The pupal period lasts for 5–8 days.

Damage pattern

The larvae feed on the foliage. When the tender leaf buds are infested, symmetrical holes or cuttings are seen when the leaves are unfolded.

Economic threshold level

10% leaf damage

Management

- Growing sunflower as a border or intercrop in groundnut helps to trap *Helicoverpa*.
- Monitor the emergence of adult moths by setting up light or pheromone traps (five per acre).
- Avoid monocropping.
- Optimise use of nitrogenous fertilizers
- Avoid migration of larvae by digging a trench 30 cm deep and 25 cm wide with perpendicular sides around the infested fields.
- Application of nuclear polyhedrosis virus (NPV) @ 250 LE/ha with crude sugar (2.5 kg/ha) in the evening hours is effective. Grow castor as a trap crop.
- Do crop rotation with sorghum, maize, bajra and sugarcane
- Release of *Trichogramma* egg parasitoids @ 7.5 cc/ha.
- Dilute 200 ml of *Prosopis* leaf extract with ten litres of water and spray.
- Set up bird perches.

Beneficial insects

Pentatomid bugs, syrphids, ladybird beetles, lace wings, *Apanteles sp.*

DISEASES

Leaf spot or *tikka* disease

Causal organism: *Cercospora arachidicola, Cercosporadium personatum*

Tikka is a major disease-affecting groundnut (and all its varieties) in India. It occurs as well in almost all groundnut-growing countries of the world.

Symptoms

It occurs as two distinct types of leaf spot, namely, early leaf spot and late leaf spot. These are caused by two different species of fungi: *Cercospora personatum* and *Cercospora arachidicola.*

Early leaf spot

The spots caused by *C. arachidicola* are sub irregular to circular, 1–10 mm in diameter. The lesions are dark brown and appear on the adaxial (upper) surface of the leaflets. Light brown lesions are found on the abaxial (lower) surface. The lesions are larger than those caused by *C. personatum* and are surrounded by a bright yellow, circular halo.

Early leaf spot

Late leaf spot

C. personatum causes small, dark spots which enlarge to about 3–8 mm diameter. Between few to several spots appear on each leaflet. These spots often coalesce to form irregular dark brown to black patches. The spots mostly appear on the leaf blades, but at times, they also appear on the petioles and the stem. The infected leaves drop off prematurely. The disease begins to appear a month after sowing and is severe during the flowering and harvesting stages.

Late leaf spot

Disease cycle

The infection initially originates with the fungus getting carried on plant debris or through the seed. During the initial stages the infection mostly occurs on the older leaves near the ground level.

The conidia produced on these infections are disseminated by wind, rain and insects. This leads to secondary infection.

Management

Sanitary precautions such as destroying the diseased plant debris would reduce the intensity of the disease.

Intercrop groundnut and green gram (*Vigna radiata*) in the ratio of 4 : 1.

Do seed treatment with asafoetida solution.

Tolerant varieties like T-64, C-501, MH-4, TMV-6 and TMV-10 can be grown.

Rust

Causal organism:
Puccinia arachidis

Rust occurs in south and central America, West Indies, Venezuela, China and India. It is one of the serious diseases of groundnut.

Symptoms

Orange-coloured pustules or uredinia appear on the lower surface of the leaves. They rupture to expose masses of urediniospores. The spores are reddish brown in colour. Corresponding to the sori, small, brown necrotic spots appear on the upper surface of the leaves. When the infection gets severe, the lower leaves wither and drop prematurely. The kernels formed in the infected plants are small and shriveled. The disease may occur on all aerial parts of the plant apart from the flowers and pegs. It occurs when the crop is over six weeks old.

Disease cycle

The pathogen is known by its uredinial stage. The dissemination of groundnut rust is by means of urediniospores.

Management

- Diseased plants should be removed and destroyed.
- Heavy growth of weeds may encourage disease development. Hence, they should be kept under control.
- Monocropping of groundnut should be avoided.

Alternaria leaf spot

Causal organism:
Alternaria helianthi

The disease commonly occurs in all varieties during the winter season and spreads rapidly during the rainy season.

Symptoms

The fungus causes brown spots on the leaves. They may also appear on the sepals, petals and stem. The lesions on the leaves are dark brown with a pale margin and a yellow halo. They are initially smaller in size and gradually enlarge up to 2–3 cm in diameter and form irregular circular lesions.

Stem rot

Causal organism:
Sclerotium rolfsii

Stem rot is a most important disease of groundnut in the USA. In India it occurs sporadically and causes yield loss of up to 27%.

Symptoms

The fungus attacks all parts of the plant but stem infection is the most common and serious. The branches that are in close or partial contact with the soil start wilting. The affected plant parts turn brown and small round bodies of about the size of a mustard seed are produced on the surface of the affected tissue. The leaves turn yellow and then brown and later desiccate. As the infection gets severe, a white thread-like fungal growth can be seen near the soil surface or just below the ground level. The entire plant may get killed or the branches of the plants alone may get affected. Infection of the pegs results in poor development of pods.

Disease cycle

The fungus is facultative and has a wide range of hosts. The sclerotia can survive in the soil for many years. The fungus multiplies readily on fallen leaves and branches. It is seed borne and present both internally and externally in the form of mycelium. Soil moisture plays an important role in fungal infection. At 40–50% soil moisture, the infection level can be high.

Management

- Infected plant debris should be collected and burned periodically.
- Crop rotation helps to keep the disease in check.
- Control of leaf spot disease prevents leaf dropping and indirectly controls stem rot by reducing the availability of nutrients to the pathogen.

Nutrient deficiency

Zinc

Zinc deficiency is most common in sandy and sandy-loam soils. Zinc deficiency usually results in reduction of flowers, poor development of pegs, root and shoot.

Boron

This deficiency has been reported in Punjab and Tamil Nadu. The threshold value for boron is 0.25 ppm. The deficiency causes hollow heart.

Iron

Lack of sufficient iron in the soil causes iron chlorosis, a condition that has been reported from Tamil Nadu, Gujarat, Karnataka and Maharashtra. It also occurs in calcareous black soils and sandy loams.

HARVESTING

Harvesting usually consists of a series of operations – digging, lifting, winnowing, stocking and threshing. Depending on the system used, some of these can be combined or eliminated. During harvest, pod loss is more with the Virginia type than the Spanish types. The loss may be due to various reasons such as harvesting after the optimum maturity period, early harvesting, method of harvesting, excess soil moisture, soil moisture deficit, etc. Soil moisture level is very critical during harvesting. At the time of digging, soil moisture is most important both to reduce pod losses due to poor peg strength and *in situ* sprouting of seed. When the

crop reaches its physiological maturity, irrigation should be stopped. At the same time, it should be maintained at the optimum level during the harvest.

Timing of harvest

Groundnut shows indeterminate growth. The flowering occurs over 2–3 months according to the type of variety. Hence, pods of different sizes can be found during harvesting. The time for harvesting can be determined by pulling out and examining the plant at random. At maturity, yellowing of the top leaves and drying and shedding of older leaves are observed. Spanish and Valencia types of groundnut usually mature 110 to 130 days after sowing, while the Virginia types takes 130 to 150 days. Once the pods are mature, they should be harvested without delay. Harvesting at the right time helps to obtain good yields of pods and oil. If they are not harvested at optimum maturity, they are prone to Aspergillus attack; late harvesting also results in sprouting of pods in the field. The nut takes two months to attain full development. A fully mature pod will be difficult to split easily with finger pressure. This stage is achieved when the vine begins to turn yellow and the leaves start shedding. Delay in harvesting may result in substantial loss in yields.

Method of harvest

The bunchy varieties are harvested by hand and the spreading varieties by digging, ploughing or by working with a blade-harrow. Groundnut should be harvested in bright sunshine so that the pods and vines can be dried thoroughly. Prevalence of high humidity during harvesting leads to development of mould in pods.

Special techniques

There are chances of the groundnut pods germinating before harvesting. This can be avoided by providing a foliar application of *Prosopis* pod extract or 20% neem seed kernel extract. To prepare the extract, 100 kg of powdered *Prosopis* pods or neem seed kernels are soaked in 200 litres of water and filtered through a muslin

cloth. The extract is diluted to 500 litres for spraying in one hectare of groundnut crop. The use of this extract is effective in inducing dormancy up to 11 days.

Yield

Yield varies in different states. It is determined by factors such as rainfall, soil type, management and crop protection practices. The yield is usually higher in the Virginia-runner type than in the Spanish-Valencia type. The yield of an irrigated crop in the summer is more than double that of a *kharif* crop. Under rain-fed conditions, the average yield of semi-spreading and spreading varieties is 1.2–1.4 tonnes of pods per hectare and that of the bunch type is between 0.8–1 tonne/ hectare.

POST HARVEST MANAGEMENT

Stripping

Stripping is the process of removing groundnut pods from the haulm after lifting, and usually, drying. After harvest, the pods should be immediately stripped off from the plants or after a few days of drying in the sun. Stripping is normally done by hand and is a tedious and time-consuming operation. The pods are usually removed by picking or flailing.

Drying

The pods should be dried in the sun for at least 7–10 days to obtain a safe moisture level. If by chance the pods are stored damp, there are chances of mould development and this may result in aflatoxin contamination.

Packaging and storage

The moisture content of the pods should be less than 10% during storage. Spread husk or sand or wooden boards on the floor of the storage rooms to inhibit moisture contamination.

Groundnut pods can be stored for about 6–7 months by using camphor. This is a common farmer's practice: the fully dried groundnut pods are filled in polythene lined gunny bags to a height of 30 cm after which a few pieces (8–10) of camphor are placed in them before filling them further. After the entire bag is filled up, its mouth is tied tightly.

The bags are kept in a moisture-free area. This work has to be completed before the onset of the monsoon.

For every 400 kg of groundnut, mix 2 kg of neem leaves. This will act as a repellent for storage pests.

Shelling

Shelling is usually carried out when the moisture content of the pod is less than 10%. Shelling is done by hand or with the use of a pedal-operated groundnut decorticator or hand-operated sheller.

STORAGE INSECTS

Groundnuts and groundnut products are attacked by several species of insects in storage, causing heavy damage. Approximately 6 to 10 percent of the groundnut stored is destroyed by insects even after being stored in bags. According to the literature, there are nearly a hundred insect species that infest stored groundnut. Factors such as moisture content, method of storage and pod maturity at harvest determine the amount of deterioration. Insect infestation leads to an increase in the level of free fatty acids in the kernels and ultimately results in reduction in quality. In extreme cases, the damaged kernels even lose their capacity to germinate.

Mould development is also encouraged by the heat and moisture generated by large insect populations within heaps or stacks. Harvest and post harvest operations such as curing, drying, threshing and handling have a great impact on the degree of infestation in storage. Mature pods are less susceptible to deterioration than immature pods. Damages caused during post harvest treatment such as the development of crack on the pods, etc., boost the susceptibility of pods to pest attack. Careful handling during post harvest operations helps to reduce such problems.

Rust-red flour beetle (*Tribolium castaneum*)

Red flour beetle is considered to be a major pest of shelled groundnuts. It is found throughout the tropics. The female lays about 450 eggs at random in the produce. The cylindrical larvae

that hatch out of these eggs feed on the kernels. Pupation takes place inside the nuts without a cocoon. The adult beetles which damage the kernel, survive for about eighteen months. The developmental period – from egg to adult – is about twenty days. Red flour beetle has been found to cause 4.5% losses in weight and 73% losses in germination. As a result of the damage, free fatty acid content of the groundnut oil increases, resulting in deterioration of its quality.

Saw-toothed beetle (*Oryzaephilus surinamensis*)

Adult beetles are about 2.5 mm long and brownish; the thorax bears six saw-tooth-like projections on each side. The whitish larva has a brown head, which is small, slender and slightly longer than the adult. Each female is capable of laying 300 eggs loosely on groundnuts. Both adults and larvae feed on the produce and the adults may live for up to three years.

Tropical warehouse moth, Almond moth (*Ephestia cautella*)

This pest is common throughout the tropics but is less prevalent in arid areas. It commonly infests stored shelled groundnut. It is a dull greyish brown moth. The forewings have obscure markings, with an outer pale band and broad dark band with a broad pale band on the inner edge. The adult avoids strong light and rests in dark places during daylight. The female lays up to 300 eggs in the groundnut produce often by simply dropping the eggs through holes between the fibres in jute bags or by laying eggs liberally on the surface of the kernels. The larvae move freely through the produce contaminating it with webbing and frass. They feed on the kernels until they are mature. In optimum conditions at 28 °C and 70 percent RH, the eggs hatch in three days, develop from egg to adult in about 24 days and complete their life cycle within 40 to 50 days.

Rice moth (*Corcyra cephalonica*)

This species of moth has the ability to develop at low humidity (<20 percent RH). The adult is brown and 12 to 15 mm long with its wing folded. The head bears a projecting tuft of scales. The

female lays up to 150 eggs within a few days of emergence from the cocoon. The larvae feed upon and within the kernels. Infestation causes aggregation of kernels by the presence of webbing. The development period at optimum temperature is four to five weeks. The larvae are capable of damaging intact kernels and can feed both on the surface and within the seed. They spin a tough silky fibre, webbing together kernels and frass and cast larval skins.

Merchant grain beetle (*Oryzaephilus mercator*)

This species is cosmopolitan in distribution. The adults are 2.5 to 3.5 mm long with a distinctive ridged prothorax bearing six large teeth on either side. Each female lays about 300 eggs loosely in the groundnut over a 10-week period. The eggs hatch into cream coloured larvae, which move freely until fully grown. Both adult and larvae feed on the produce and the adult may live for as long as three years. The life cycle is completed in four to five weeks under optimum conditions at 30 °C and 70 percent RH. The adult and larva burrow into the groundnut seed causing 'warm-cut' groundnut and an increased percentage of split seed. Losses occur through contamination of the product by live and dead insects, cast skins and excrement.

Groundnut borer and weevil (*Caryedon serratus*)

This species is found in India, Gambia, Senegal, and West Africa. It breeds on common trees such as *Tamarindus indica L.* and harvested groundnuts. It can penetrate intact pods to infest the kernels. Infestation of the harvested groundnuts can occur while the crop is being dried in the field, stored near infested stocks or crop residues. Adult females attach their eggs to the outside of pods or kernels. When the first instar larva hatches, it burrows directly through the pod wall to reach the kernel, where the larva feed and develop. A single larva can make a large excavation in the cotyledons, but no sign of damage is visible externally at this stage. Mature larvae emerge partially or completely from the pod and

construct an oval papery cocoon. The egg to adult development period is about 42 days. The adult is 4 to 7 mm long, with small black markings on the elytra. It is readily distinguished from the other pests of groundnuts by its very broad hind femur, serrate antennae and elytra that do not completely cover the abdomen.

Elasmolomus sordidus This bug is widespread in tropical Africa and India, occurring on pods left for drying in the field and in storage. The adult is dark brown, approximately 2 mm wide. In the field females lay their eggs in the soil or on groundnut haulms. In storage, eggs are laid loosely among the groundnuts or in the sacking. The first instar nymphs have a bright red abdomen; later instars become progressively darker. All stages feed on kernels, perforating the pods with their rostrum. This causes the kernels to shrivel and increases the free fatty acid content of the oil, producing a rancid flavour.

Indian meal moth (*Plodia interpunctella*) This species is more frequently found in cooler areas of the tropics. The basal third of the forewing of this moth is a pale yellowish buff colour. The remainder is reddish brown. The larvae feed on and within kernels and spin a silken thread on which the larval droppings accumulate. Females lay about 500 eggs at a time. Development from egg to adult takes about 26 days. The life cycle of this moth may be prolonged by diapause under certain temperature conditions. During diapause the metabolic activities are very low and normal application rates of control chemicals, especially use of fumigation, may not prove effective.

Black fungus beetle (*Alphitobius sp.*) These species (*Alphitobius diaperinus* and *A. laevigatus*) are 5 to 7 mm long. They feed upon damp kernels, groundnut cake and other grain residues. Their presence in groundnut storage and oil extraction mills is indicative of poor storage conditions involving spillage and dampness.

Storage management

- Groundnut must be dried properly after harvest to reduce the moisture content of the kernels to 7% for safe storage. At high moisture levels, insect populations develop more rapidly and there is an increased risk of invasion by toxic fungi, with a consequent danger of aflatoxin contamination.
- The stacks should be piled on wooden pallets to reduce the possibility of ground water seeping into the bottom sacks.
- Plant materials such as crushed neem seed, neem leaves or neem oil, which have antifeedant or repellant effects on storage pests, can be used.
- Storage godowns should be kept clean. All the waste and unwanted materials in the godown should be periodically removed.
- The gunny bags should be stacked with proper aeration.
- The gunny bags bought for seed storage should be treated with 10% neem kernel extract before they are used. The neem kernel should be used immediately after preparation. The gunny bags should be soaked in the extract for 15 minutes. The gunny bags should be shade dried and used for storing grains. In case the gunny bags are new they should be soaked for half an hour. If the gunny bags are with a close mesh and small pores, a thinner solution should be prepared. By this method, the grains can be protected from insects for about four months.
- Storage godowns or rooms should have proper ventilation and aeration.

OKRA

Tamil – *vendai*

BACKGROUND TO THE CROP

Okra (*Abelmoschus esculentus*) is an annual vegetable crop grown in the tropical and sub-tropical regions of the world. It is the sixth important vegetable crop cultivated throughout India. It is a member of the Malvaceae family and can be found as an annual or as a perennial crop in the country. The fruits are rich in fibre content and are gummy, slimy and mucilaginous. Okra also has a high iodine content which helps to control goitre.

Area and production

As per 2001–02 data, the total area under okra cultivation in India was 3.472 lakh hectares with a total production of 3.24 lakh tonnes. The average productivity was 10.1 tonnes/ha. Leading okra producing states in India are Uttar Pradesh, Bihar, Orissa, West Bengal, Gujarat, Maharashtra and Andhra Pradesh. In India, okra's share is 3.8% of the total vegetable production.

Climate

Okra is a tropical vegetable and requires a long, warm and humid growing period. It grows even at an altitude of 1,200 m. It thrives well in hot humid areas and is well suited for tropical and subtropical regions. Temperatures between 24 °C and 28 °C are preferred for normal growth and development. The seeds do not germinate below 20 °C. The crop is sensitive to frost and will not thrive when there is a continuous cold spell. Higher temperatures help in faster plant growth though they may delay fruiting. However, very high temperatures are not favourable and beyond 40–42 °C, flowers drop, causing yield loss. Adjustment of climatic factors helps in taking one (summer) crop in the hills, two or even three (summer, *kharif*, and late *kharif*) crops in east, west and north India and almost year-round cultivation under a moderate climate in south India. For good seed germination, optimum soil moisture

and temperatures between 25 °C and 35 °C is best. Beyond this range, delayed germination is observed and some seeds may not even germinate.

Intercrops and crop rotation

Okra can be grown in different cropping systems. The crop responds to high doses of fertilizers and indicates better utilization of nutrients under intercropping conditions. Good returns can be obtained when okra is grown along with French beans or radish. The following cropping pattern – okra-cowpea-maize, maize-okra-radish and okra-okra-radish – reduces bacterial wilt in tomato and brinjal grown as succeeding crops. With sugarcane, it is reported to increase the yield of cane as per a trial carried out in Nepal.

Growing season

In south Indian conditions, the crop can be grown throughout the year since frost and severe winters are absent. In north India, two crops are usually raised in a year. The summer crop is sown during February–March and harvested between April–June. The rainy season crop is sown during June–July with the onset of rains and harvested between August–October. For the summer crop, early maturing five ribbed cultivars with smooth pods are preferred and for the rainy season, late maturing five to eight ribbed cultivars with smooth or hairy pods are grown. A few cultivars are suited for both the seasons.

Soil

The crop is adapted to a wide range of soils from sandy loam to clayey loam. But due to its well-developed tap root system relatively light, well drained, loose, friable and well-manured loamy soils are preferred. A pH between 6–6.8 is ideal. Before sowing, enrichment with organic manure is needed for all soil types. Okra can also be grown in mild salt affected soils.

Crop duration

The total crop duration is between 90 and 120 days.

VARIETIES

Pusa Sawani, developed as an open pollinated variety, prevailed across the country for more than two decades. With the breakdown of its tolerance to yellow vein mosaic virus, around fifteen to twenty varieties have been developed by different organizations and released for cultivation. The popular okra varieties today are Arka Anamika, Pusa Sawani, Pharbhani Kranti, Janardhan, VRO-5, Pusa Mukhmali, Varsha Uphar, VRO-6, Pusa A-4, and Utakal Gaurav, etc.

Besides these, local varieties are still being grown, particularly by organic farmers.

Some of the popular local varieties of Tamil Nadu are Bangalore local, Kulemagali Vendai and Nattu vendai (JRDP).

SEED

Selection

For seed purposes, harvesting is done 30 days after anthesis – when the pods are fully mature, dry and start cracking. About 300 plants (left for seeds) are sufficient to sow one hectare of crop.

Treatment

For the summer crop, the seeds should be soaked in water for 12 hours before sowing.

The seeds can be treated with sweet flag rhizome extract or cow urine solution (diluted with water in 1 : 5 ratio) for 30 minutes before sowing. This gives resistance against a number of bacterial and fungal diseases.

Seeds can also be treated with cow dung solution (viz, *beejamrut*/*jeevamrut*/*amrut pani*/*panchagavya*) for 4–6 hours after soaking in water for eight hours. The seeds can then be dried in shade and sown.

Seed rate

A seed rate of about 18–22 kg/ha for the spring/summer crop and 10–12 kg/ha for the rainy season crop will be optimum. A higher seed rate is used for the spring crop since it has to augment the loss in germination due to low temperatures.

A high seed rate and closer spacing during summer reduces field temperatures and helps in normal fruiting under frequent and light irrigation.

CULTIVATION

Field preparation

Okra requires a well-prepared seed bed. Four to five ploughings are necessary to bring the land to a proper tilth.

Sowing

Okra gives little success on transplanting and hence the seeds are directly sown in the field. Sowing is done either by dibbling or by using a seed drill or are sown behind a plough. It is not common to broadcast the seeds on occasion.

Ridge sowing ensures good germination and reduces water requirement for the summer crop and helps in drainage during the rainy season. The seeds should be dibbled at the rate of 2–3 per hole.

To get a continuous supply of fruits, it is preferable to sow the seeds in batches at intervals of 2–3 weeks during the growing season.

Spacing

Spacing differs for different varieties and hybrids. The seeds should be sown on ridges 30 cm apart. The spacing between two ridges should be maintained at 45 cm. For branching and robust types, a planting distance of 60 cm between rows and 30 cm between plants is ideal. For hybrids, the spacing adopted is 75 x 30 cm.

Intercultural operations

Thinning out closely germinated plants should be done at one true leaf stage.

Weeds

The plants respond well to intercultural operations and weeding. Hoeing and weeding should be done at regular intervals based on requirement. Proper weed management can save up to 90% crop loss from weeds. The time for the first weeding is when the seedlings are 20 days old; subsequent weedings can be done at intervals of 25 days. A total of 3–4 weedings can be carried out

from 20 days after sowing till the crop canopy covers the soil surface at regular intervals. Earthing up is done 30 days after sowing.

WATER REQUIREMENTS

A pre-sowing watering should be given if there is insufficient soil moisture. There should be enough soil moisture at the time of sowing to help in proper germination. The crop should be irrigated after germination when the first true leaves initiate for the summer crop and when the leaf expands for the rainy season crop. Subsequent irrigations can be given at 4–5 days' interval for the summer crop and whenever required for the rainy season crop. At high temperatures of about 40 °C, frequent light irrigations should be given for proper fruiting. The soil should be kept in a moist condition, but water logging should be avoided to prevent wilting of the plants.

It is not a common practice to use drip irrigation commercially for okra though it saves 85% of the water used. Irrigation through furrows is commonly practised. Moisture stress during flowering and fruit set causes about 70% crop loss.

Training and pruning

Normally, okra does not require training or pruning, since the plants are erect and grow upright. It does not require staking either. But in crops sown during the summer, pruning the plants at about 20–25 cm from ground level after rains, when harvesting is over, has been tried in recent years. Varieties like Arka Abhay and Pusa A4 give quick branching after pruning.

MANAGING SOIL FERTILITY

Continuous application of farmyard manure year after year increases the yield of green fruits. Farmyard manure is applied @ 25 tonnes/ha. Neem cake is applied @ 250 kg/ha and groundnut cake is applied @ 80–100 kg/ha. Two kilograms each of biofertilisers like azospirillum and phosphobacteria are used.

PROBLEM INSECTS

Insects and disease are a major threat to okra cultivation and bring about a considerable loss in yield. A major part of the cultivation cost is incurred for crop protection. A list of major pests and diseases in okra is given below, along with organic control measures:

Shoot and fruit borer (*Earias vittella, E. insulana*)

This is also one of the common pests in cotton and attacks a large number of malvaceous plants. Infestation and damage to crops is more in summer. The insect is distributed widely throughout India.

Life cycle

The total life cycle of the insect is completed in 30–40 days. The adult moths are about 13–15 mm with a pale brownish white head and thorax. The hind wings are creamy white in colour. In *E. vittella*, the forewings are pale white with a broad, wedge-shaped horizontal green band in the middle whereas in *E. insulana* the forewings are uniformly green in colour. Eggs are spherical with longitudinal ridges, single and light bluish green in colour. They are laid singly on buds, flowers, fruit or on shoot tips. The larvae are stout, brown in colour with white markings. The pupae are found in inverted boat shaped silky cocoons.

Symptoms

The larvae bore into tender shoots and move downwards, creating a tunnel inside. The growing points are affected and hence side shoots may arise. The affected shoots wither and droop. The caterpillars also bore into the buds, flowers and fruits and feed on the inner tissues. The damaged flowers fall off and the affected pods are malformed.

Economic threshold level

The economic threshold level is 10% damage to the crop.

Management

- Sowing in the first week of June is ideal to avoid damage of shoot and fruit borer during the rainy season.

- Summer ploughing should be done to destroy bollworm pupae.
- Spray ginger, garlic, chili or Sida acuta kashayam.

Leaf hoppers (*Amrasca biguttula biguttula*)

This is a polyphagous pest found widely infesting okra, cotton, brinjal, castor, beans and cucurbits.

Life cycle

The adults are 2 mm in size, wedge-shaped, pale green in colour with two black spots on the vertex and a single black spot on the posterior half of each forewing. The nymphs are translucent and yellowish green in colour. They insert their eggs into the tissues of the veins on the under surface of the leaves.

Symptoms

The nymphs and adults suck the sap from the under surface of the leaves and inject toxic saliva into the plant tissues. The affected leaves first turn yellow, then brick red, before they become brittle and fall off. In cases of severe infestation, the fruits are also affected. Climatic factors like cloudy weather play an important role in population build up. Heavy showers wash off the nymphs and adults.

Economic threshold level

The economic threshold level is the presence of one to two nymphs or adults per leaf.

Management

- Install yellow sticky traps @ 30/ha
- Spray 5% neem seed kernel extract or ginger, garlic, chili extract or Sida acuta extract.

Fruit borers (*Helicoverpa armigera, Spodoptera litura*)

Life cycle

The eggs are yellowish white in colour. The caterpillars are of varied colours, mostly dark greenish brown or apple green. They have whitish or dark grey longitudinal lines with white stripes on the

lateral side. The adult moths are medium sized, stout and pale brownish in colour. The forewings are pale brown in colour. They have indistinct wavy lines along the margin with a dark brown spot at the centre. The hind wings are smoky white in colour with a blackish outer border. The pest completes about four generations in a year. Eggs are yellowish-white in colour and dome-shaped. The eggs laid in the leaf buds hatch in 2–5 days. The larvae pass through six instars. When the larvae are fully grown, they burrow into the soil to a depth of 2–18 cm for pupation. The pupae are smooth, 14–18 mm long. The pupal period lasts for 5–8 days.

Damage pattern

The larva feed on the foliage. When the tender leaf buds are infested, symmetrical holes or cuttings are seen when unfolded.

Management

- Adopt summer ploughing to destroy bollworm pupae.
- Place 15–20 bird perches per hectare. This invites predatory birds
- Mix one kilogram of fenugreek (*Trigonella foenum-graecum*) flour with two litres of water and keep aside for 24 hours. Then add 40 litres of water to the mixture and spray in one-hectare area. This ensures fifty percent control within seven days.
- Prepare an herbal pesticide by boiling 4 kg of aloe (Aloe vera), 500 ml of neem oil and 500 gm of tobacco powder in 20 litres of water. Boil the contents for 3–4 hours until it reduces to one-fourth of the original volume. Allow it to cool, add 50 gm of soapnut (*Sapindus emarginatus*) seed powder and mix thoroughly. Dilute 100–150 ml of this filtrate in 15 litres of water and spray.
- Install pheromone traps @ 8 per hectare.

- Spray 5% neem seed kernel extract or *Andrographis kashayam* or five leaf extract to kill early stages of the larvae
- Use biocontrol agents like *Trichogramma* @ 50,000 eggs/ha six times at weekly intervals.

Other minor pests

- Aphids – *Aphis gossypii*
- Thrips – *Thrips tabacii*
- Red cotton bug – *Dysdercus cingulatus*
- Leaf rollers – *Sylepta derogate*

Beneficial insects

Crickets, ants, wasps, ladybird beetles

DISEASES

Yellow vein mosaic / Vein clearing (Vector: White fly – *Bemisia tabaci*)

This is the most important factor limiting cultivation of okra throughout India. This viral disease is prevalent wherever the crop is grown especially during the rainy season. If the plants are affected during the early stages of growth, there is a total loss of yield. If infection is found within 35 days of germination, the crop growth is retarded with very few leaves and fruits. Damage may be to an extent of about 94 percent. Plants infected at 50 and 65 days after germination suffer a loss of 84 and 49 percent respectively. The extent of damage declines with the delay in infection.

Yellow vein mosaic symptoms

Symptoms

The major symptoms are vein clearing and veinal chlorosis of leaves. The yellow network of veins is conspicuous and the veins and veinlets are thickened. The veins turn yellow throughout the entire leaf blade. In cases of severe infection, the younger leaves are yellow in colour, reduced in size and the plant remains stunted. Leaves continue to show symptoms as they are formed, throughout the growing season. The infection prevents the formation of flowers and fruits. If formed, the fruits are small, malformed, hard and yellowish green in colour. Such fruits do not fetch a good price in the market. The conditionmay affect many plants in the field and may occur at any stage of the plant's growth. Varieties like *Parbhani Kranti*, *Arka*

Anamika, *Arka Abhay*, *Janardhan* and *Haritha* are reported to be tolerant to yellow vein mosaic. No known variety is reported to be completely resistant to the disease.

The causal agent

The disease is caused by the Yellow Vein Mosaic Virus (YUMA). Normally it is not sap transmissible. But under experimental conditions, it has been transmitted by grafting. Not much is known about the nature and properties of this virus. It is transmitted by white flies (*Bemisia tabaci*) and the okra leaf hopper (*Empoasca devastans*). The wild hosts of the virus include rail weed (*Croton sparsiflora*), and goat weed (*Ageratum sp*).

Disease cycle

The insect vectors transmit the virus from wild hosts to the main crop. The disease is not seed borne. A continuous cycle is maintained through wild or cultivated hosts. Climatic factors favour the population build up of vectors and the prevalence of wild hosts.

Management

- Cut a cactus like nawagalli (*Euphorbia nivulia*) or milk bush (*E. tirucalli*) into pieces, immerse in water (just enough for the pieces to float), allow to ferment for 15 days, filter and spray.
- Control the vector by spraying 5% neem seed kernel extract or ginger, garlic and chili extract.
- Destroy weeds and other wild hosts wherever possible.
- Remove the affected plants from the field and burn them.
- Avoid summer season planting.
- Plant resistant varieties like Parbhani Kranti, Arka Anamika, VRO-5, VRO-6 and Pusa A-4 (Co-2 is susceptible to YVM).

Cercospora leaf spot (_Cercospora abelmoschi, C.malayensis, C.hibisci, C.hibiscina_)

Several species of *Cercospora* are reported to cause spots and blight. The pathogen affects the crop often during humid weather conditions and causes defoliation. *C. abelmoschi* produces no definite spots but produces a sooty black mould on the lower surface of the leaves. *C. malayensis* produces irregular brown spots with a grey centre and dark margins. The fungal spores survive as conidia and stomata on crop debris. A temperature of about 24–29 °C is highly conducive for infection.

Management

- Clean and trim all the bunds.
- Spray 10% cow urine or 5% neem seed kernel extract.

Powdery mildew (_Erysiphe cichoracearun_)

A fungal disease, characterized by grey-coloured powdery growth on both the upper and lower surface of the leaves. It severely affects the yield of the crop but can be controlled by applying 10% lime water.

Root knot nematode

Causal organism: _Meloidogyne incognita, M. javanica_

Disease incidence is widespread in both summer and spring in north India. Root knot or root galls caused by nematodes are a common disease of many vegetables in tropical and sub-tropical climates. An infection weakens the plants and pre-disposes them to the invasion of many root rot and wilt causing fungi and bacteria, thus compounding the damage.

Symptoms

The plants remain pale and stunted, and pod set is very low. The leaves are yellowish green or yellow in colour. Drooping, sudden wilting together with a scorching of leaves from the margins inward can be observed. Formation of knots or galls in the root system is a characteristic symptom. The maximum number of galls per plant and number of females and egg masses per gram of root occur when the plants are infected at 2-week stage. The main root and the laterals have spherical or elongated galls of various sizes. In

advanced stages of infection, the tissues decay and are attacked by other pathogenic and saprophytic organisms.

Cultivars like long green smooth, IC-9273 and IC-18960 are reported to be resistant to root knot nematodes.

Causal agent

Meloidogyne incognita is abundant in cooler and warmer areas whereas *M. javanica* is common in warmer areas. The nematodes are sedentary endoparasites of roots. The female lays eggs in the host root tissues in masses or egg sacs. The eggs are dormant and do not hatch immediately. An average of about 400–500 eggs are found in a single egg mass. The eggs hatch under suitable environmental conditions. Newly hatched larvae are small, slender and about 0.3–0.5 mm in length. Their movement in the soil is slow and on contact with host roots the larvae enter the roots just above the root cap. Upon entering the roots, they move between the undifferentiated cells and reach the endodermis where they become sedentary. They eject secretions while they feed on the cells, which cause enlargement of cells or formation of galls. It is very difficult to control nematodes in an infested field since the eggs survive in the soil and are protected by host tissues. They are introduced through infected seedlings and by shifting soil from neighbouring infested fields.

Management

- Crop rotation – There is a wide host range for nematodes. With cereals, there is a definite reduction in the population.
- Intercropping with marigold is helpful in minimising the infestation.
- Add organic amendments like neem cake @ 25 q/ha.
- Fungal species such as *Paecilomyces lilacinus* and *Verticillium* and the *bacterium Bacillus penetrans* can be used as bio-control agents.

Other minor diseases

Fusarial wilt	– *Fusarium oxysporum f. sp. vasinfectum*
Damping off	– *Pythium sp.*
Fruit rot	– *Pytophthora sp., Pythium sp.*
Leaf spot	– *Alternaria hibiscinum, Phyllosticta hibiscini*
Anthracnose	– *Colletotrichum capsici, C. hibisci*

General management of diseases

- Spray mint leaf extract (250 gm of leaf powder in two litres of water)
- Spray 10% cow urine thrice at 10 days' interval.
- Spray 5% neem seed kernel extract
- Fumigate with *vaividanga* (*Embelia ribes*) or sweet flag (*Acorus calamus*) twice during the evening hours.

Other disorders

Pod discolouration

When okra pods are discoloured (light yellow or white), spray leaf extract of mesquite (*Prosopis juliflora)* diluted with water.

HARVESTING

Timing

Depending upon the variety and season, the harvesting period varies between 45 and 65 days after sowing. Size of the pods and the stage at which they are harvested vary with the variety or hybrid and market preference. Generally, medium sized (7–10 cm long) tender pods, which can be easily snapped from the plant, are harvested. They attain this size in 4–6 days after the flower opens. As all the fruits do not mature at the same time, harvesting is carried out once in 3–4 days. Frequent picking promotes fruit development and prevents the pods from growing too large. Normally harvesting is done during morning hours. The crop can also be harvested during evening for transporting to distant markets.

Method of harvesting

The fruits are handpicked; hand gloves or cloth bags are used to protect fingers. The fruits can be harvested on all alternate days. Early harvesting results in low yields of tender fruits with a short shelf life.

Flowering and fruiting intensity reduces in plants which are not regularly picked for tender pods.

Yield

Yield varies greatly depending upon the variety and season of cultivation. On an average, okra yields 7.5–10 tonnes/ha while the yield of hybrid varieties ranges from 15–22 tonnes/ha.

POST HARVEST MANAGEMENT

Grading

The fruits are graded based on size. Long fruits are preferred for fresh markets; 6–8 cm long fruits are sorted for the processing industry and export.

Sorting

Packaging

For local markets, the fruits are filled in jute bags or baskets, covered, and water sprinkled over them. This helps in cooling the fruits as well as maintains turgidity, which saves the fruits from blemishes, bruises and blackening. If they are packed in airtight containers, the fruits turn pale due to the heat generated by them during transport. For export, pre-cooled fruits are packed in 2.5–5 kg perforated paper cartons that are well ventilated and preferably with a lid. Tender, dark green fruits of 6–8 cm size are generally preferred for export and they are transported in refrigerated trucks.

STORAGE

Shelf life of okra can be extended up to 8 or 10 days by storing the pods at 7–10 °C and 95% relative humidity. Okra is sensitive to temperatures below 7 °C even for a short time which can result in discolouration, pitting and decay.

Temperatures above 10 °C cause yellowing, toughening and rapid decay.

Preservation of seeds

Long, lustrous and well-matured okra fruits should be selected from the standing crop. A vertical cross-section should be made in them and ash inserted through the gap. The whole fruit along with the seeds are preserved till the next year or growing season using this method. Ash is widely used for covering seeds.

Transportation

Maintenance of a cool chain from the farm to the customer is essential for transport of export commodities like okra. This can be achieved by cold storing the produce at the farm and using refrigerated trucks to transport the produce to the airport. For local markets, the produce is transported through road/rail in bamboo baskets or gunny bags.

Uses

The tender pods are consumed as a vegetable. They are also used as a thickening agent in soups and gravies. Drying, quick freezing, canning or pickling preserves the pods. *Desi* okra (mucilaginous green stems) can be used in sugar precipitation and separation of impurities during cane crushing. The dry seeds contain 13–22% good edible oil and 20–24% protein. The oil is used in soap, the cosmetic industry and as vanaspati, while protein is used for fortified feed preparations. The crushed seed is fed to cattle for milk production and fiber is utilized in the jute, textile and paper industry.

ORGANIC OKRA CULTIVATION

Case study of ratooning in okra

Shashikantbhai, a farmer from Gujarat, successfully practised ratooning in okra. He pruned his plants when market prices fell by cutting off the stems upto a foot high. Thereafter he used fertilizer, and irrigated the crop and followed all the routine procedures like inter-culturing, etc. The ratoon crop responded rapidly and new branches emerged within a week. The first picking from the ratoon crop was after 30 days. About 30 pickings at intervals of 2–3 days

gave a yield of 12 tonnes from 0.24 ha. Prof. K. D. Solanki (Gujarat Agricultural University) has drawn attention to the fact that only some varieties of okra have the characteristics of ratooning and they are also highly sensitive to pests and diseases.

Organic cultivation fetches good yield

Mr. Chinnasamy from Dindigul district cultivated okra in 30 cents organically. He applied farmyard manure and neem cake as a basal manure; top dressing was done with neem cake. The primary weeding and earthing up was done 30 days after planting. Biopesticides and *panchagavya* were sprayed 15 days after planting and again at 15 days intervals. He harvested 220 kg of fruit from 30 cents.

TOMATO

Tamil – *Thakkali*

BACKGROUND TO THE CROP

The tomato (*Lycopersicon esculentum*) is an important member of the family Solanaceae. It is one of the most nutritious and remunerative vegetable crops of India. The fruits are used either raw or ripe-raw for culinary purposes, and ripe for processing into various canned products including juices, ketchup, sauces and pickles. Ripe fruits are a rich source of minerals, vitamins and organic acids. The tomato is the world's most important vegetable crop next to the potato and it tops the list of canned vegetables. In India, tomatoes are available throughout the year being also a subsistence crop for small and marginal farmers.

With the advent of high yielding varieties for year-round production and the use of heavy doses of chemical fertilsers, a large number of pests and diseases have now emerged to cause alarming damages to the tomato crop. Bio-intensive integrated plant protection for these problems affecting tomato cultivation is the most appropriate and harmonized strategy available to ensure minimal risk to the farmer, the consumer and to the environment. This calls for standardization of organic production which has immense scope.

Origin and distribution

The tomato has its origin in the Peruvian and Mexican regions. It was introduced into Europe in the sixteenth century and later to the USA and Canada. The Portuguese introduced the crop into India. The other cultivated species is *L. pimpinellifolium*, the small-fruited tomato. The crop, though introduced from the West, has become one of the most common and important vegetables in the country. It is grown extensively in many parts of the country round the year.

Area and production

As per 2002–03 data, the total area under tomato cultivation in India was 4.78 lakh hectares with a total production of 82.71 tonnes. The average productivity was 15.9 tonnes/ha. Leading tomato producing states in India include Bihar, Uttar Pradesh, Maharashtra, Karnataka, Orissa, Andhra Pradesh, Madhya Pradesh and Assam. In India, tomato's share is 8.4% of total vegetable production.

Climate

The crop requires a warm growing season with abundant sunshine and adequate moisture. It is a warm season vegetable but is extensively grown in cooler regions as well. The plant, however, cannot stand severe frost. It can be grown at temperatures ranging between 15–27 °C. It performs well under an average monthly temperature of 21–23 °C. It can be cultivated under irrigated conditions in arid tropics, but under very high temperatures the quality of fruits is poor and there is a high incidence of sunscald. High humidity and high temperature makes the plant susceptible to foliage diseases. Excessive rain causes flower drop and adversely affects fruit set. For proper pigmentation of fruits, warm sunny days with moderately cool nights are preferable.

Growing season

In India, the crop can be grown throughout the year. In the northern plains, the crop can be cultivated during autumn and spring as well as summer. In south India, there are three growing seasons: June–July, October–November and January–February.

Soil

The crop can be grown under varied soils ranging from sandy loam to clay, black soil or red soil having good drainage. However, sandy loam rich in organic matter with a little sand in the upper layer and good clay content in the subsoil and a fairly good capacity to hold moisture is best suited for the crop. A pH between 6 and 8.5 is ideal. The crop can tolerate moderate acidity and salinity.

Crop duration

The crop duration ranges between 120–140 days for varieties and for hybrids, it is around 160 days.

VARIETIES

A large number of tomato varieties have been developed in the country. More than 25 open pollinated varieties and 10 hybrids have been released at the national level. Besides several open pollinated varieties and hybrids have been released by the respective tomato growing states and are also cultivated. In a number of states, the local varieties are still popular with farmers and these are better adapted to organic production systems. In Tamil Nadu, the local varieties cultivated include Bangalore local, *guli thakkali*, periyakulam local, pink *thakkali*, *sirsi nattu thakkali* and *Nattu thakkali*.

Varietal reaction to different pathogens

Tomato-bacterial wilt

Bacterial wilt*:* Arka Abha, Arka Abhijit (hybrid), Arka Alok, Arka Shrehta (F1) Shakti, Swarna, Lalima

Leaf curl: Anmol, Avinash-2 (hybrid), Aditi (Hybrid), Kashi Amrut

Blight: Hybrids like Akash, Vajra and Meghana

Verticillium and fusarium wilt: Empire, Roma, Rupali (hybrid), Rashmi (hybrid)

Suited for rainfed conditions: Arka Sourabh, Anmol, Roma, Paiyur, PKM-1, Shakti

Nematodes: SL-120, Ronita

Processing varieties: Roma and Arka Sourabh

Shelf life: Hybrids like MTH-6, Rupali and Avinash-2, Pusa Early Dwarf, Pusa Ruby, Arka Vikas, Arka Saurab, Arka Abha, Arka Alok, PKM-1, Anmol, Paiyur, Co 3, Punjab Chuhara, MTH-6.

Popular commercial varieties

Recently, a number of tomato varieties and hybrids have been identified from the AICRP on vegetable crops and released for cultivation. A few of these are Kashi Amrut (DVRT-1); Kashi Vishesh (H-86); Kashi Hemant (IIVR Sel-1); Kashi Sharad (IIVR Sel

-2) and Kashi Anupam (DVRT-2). Besides high yields, a few of these – such as the Kashi Amrut and Kashi Vishesh – are also resistant to TLCV.

SEED

The plant is propagated largely through seed, though vegetative propagation is also possible.

Selection

For seed collection, the crop is carefully examined, the off types as well as diseased ones are pulled out, and the selected fruits are allowed to ripen on the plant.

The contents of the ripe fruits are squeezed out and fermented for 2–5 days. When the seeds settle down, they are dried in sun or shade and stored in airtight containers. Good tomato seeds remain viable for about four years and the germination is between 85–90 per cent.

Alternatively, lemon juice can be used for seed extraction in place of corrosive hydrochloric acid (which is commonly used). The seeds should be treated with the juice for 2–3 hours @ 20 lemons/kg of wet seeds. The seeds treated by this method are shiny and fetch good prices in the market.

Seeds can also be extracted from ripe fruits by squeezing the fruits on well-spread rice bran (@ 1 kg rice bran for 1 kg seed). After thorough mixing and drying for 24–48 hours, the bran is separated from the mixture by a hand winnower.

Treatment

Seeds are soaked for six hours in a fermented mixture of buttermilk (3 days old) and water (1 : 4 ratio) and dried under the shade to remove excess moisture. The practice is applicable only for 6 to 12 month old seeds. Coconut or palmyra toddy can also be used as a substitute for buttermilk.

The seeds can also be treated with sweet flag rhizome extract for 30 minutes before sowing. This confers resistance against a number of bacterial and fungal diseases.

The seeds can be mixed with *Trichoderma viride* and *Pseudomonas fluorescens* (@ 5 gm/100 gm of seeds). This will help in the control of early blight and other pathogens.

Seed rate

The seed rate for commercial tomato varieties is around 400–500 gm/ha.

Nursery preparation techniques

Seeds are sown in well-prepared, raised nursery beds. For raising seedlings for one hectare about six cents of nursery area is required. Raised beds of dimensions 7.5 x 1.2 x 0.1 m are prepared. They are covered with a layer of farmyard manure and sand in equal proportion. Addition of farmyard manure should be @ 4 kg/m^2. During the summer and rainy season there may be heavy incidence of damping off. Field solarisation and seed treatment are helpful in minimising disease infection. Neem cake and groundnut cake (@ 2 kg/cent) can also be added to enrich nursery soil. The soil can be disinfected further by cultivating it well and then covering it with a clear plastic sheet so that it gets heated up thoroughly under the mid-day sun. This technique can be used for varieties that are highly susceptible to disease. Dusting of wood ash on seedlings in the nursery acts as an insect repellent and protects the young plants from pest and disease attacks. It also serves as a good source of mineral nutrients.

Soil solarisation of nursery plots by covering them with transparent polythene sheets of 200 guage for about 5-6 weeks, along with seed treatment techniques, have been standardized. If the temperature is high (<30--), then the beds are covered by green + black sheets, about 1 m above the ground with suitable support. This reduces the intensity of the radiation hitting the ground surface and reduces seedling mortality. Agro-nets are used especially for control of insects which spread viral disease.

CULTIVATION

Sowing

Line sowing of seeds may be done in the raised beds. The seeds should be sown thinly, leaving 2.5–3 cm spacing between rows. Soon after sowing, the beds should be irrigated using a rose can and covered with paddy straw or coconut fronds. Water should be sprinkled on the beds every day. The seeds germinate in 7–10 days. The plants must be hardened as they approach transplanting day. This is done by judicious adjustments of water supply and by exposing the seedlings to open weather. Spraying 4000 ppm sodium chloride can also help in hardening seedlings. They are ready for transplanting 4–5 weeks after sowing. At the time of transplanting, the plant should be about 7.5–10 cm in height, with a sturdy stem. Spraying 10% sugar solution several days before transplanting is reported to improve survival rate and to promote the plant's growth.

A hundred grams of asafoetida mixed with five litres of water can be used for treating the root portion of the seedlings. They should be soaked for 15 to 30 minutes in the solution before transplanting in the main field. This prevents soil borne bacterial diseases.

After uprooting from the nursery bed, the roots of seedlings can also be dipped in cow dung and cow's urine slurry/cow pat pit/*amrut pani*/*panchagavya* overnight before transplanting to the field. The auxins and nitrogen in the urine and dung help in better root growth and early establishment.

Main field preparation

A well prepared seed bed with 4–5 ploughings is necessary for transplanting tomato. The seedlings are transplanted on flat beds, on the sides of raised beds or ridges. The latter is preferred since it prevents the fruits appearing on the lower branches from making direct contact with the soil.

Transplanting

Transplanting can be done on small flat beds in light soils where irrigation is available and on shoulders in shallow furrows where

irrigation water is scanty. On heavy soils, the seedlings are normally transplanted on ridges.

The seedlings are transplanted in rows 60–75 cm apart. The planting distance within a row is 30 cm for determinate varieties and 60 cm for indeterminate varieties. For hybrids, the distance can be increased, based on types.

It was reported from certain trials that planting in a double row system (30 cm x 30 cm x 1m) on raised beds can generate high yields with healthy fruits. Raised bed methods need less water and the incidence of pests and disease is also low. For mechanical harvesting and for varieties suited for processing, a closer spacing should be adopted. For hybrids, the row spacing should be wide whereas a close spacing should be adopted between plants.

Spacing differs for varieties and hybrids. It ranges between 60–120 cm between rows and 30 to 60 cm between plants.

Direct sowing

The tomato is also cultivated by direct seeding. This results in early flowering, early fruiting and less incidence of pest and disease. Close spacing in direct seeding has the advantage of higher yields as well. Seeding of 3–5 seeds in a clump at 25–30 cm ensures 2–3 plants per clump. After the plants have established, thinning should be done to maintain only 1–2 seedlings per hill.

Weeds

Weeds are problematic and care should be taken especially during the initial stages of plant growth. Weeding is mostly done manually. Forty-five days after transplanting is the most critical stage of crop-weed competition in tomato. If the weeds are allowed to compete with the crop, its yield is reduced drastically. The plants require frequent shallow hoeing especially during the first four weeks after transplanting. This facilitates soil aeration for proper root development. Deep cultivation is injurious, since it causes damage to the roots and exposure of moist soil to the surface. Hoeing can

be done to loosen the soil after every watering. This process also helps in controlling weeds. Two earthing-ups are sufficient for good growth.

MANAGING SOIL FERTILITY

Farmyard manure should be applied at the rate of 25 tonnes/ha several weeks before sowing. Green manure with crops like sunhemp (*Crotalaria juncea*), cowpea (*Vigna catjang*), *daincha* (*Sesbania aculeata*) and cluster bean (*Cyamopsis tetragonoloba*) can also be used to substitute for farmyard manure to an extent. Neem cake can be applied @ 150–250 kg/ha. Top dressing can be given with groundnut cake (@ 80–100 kg/ha) after 40 days of sowing. This will help in increasing the yield as well as the size of fruits. The soil can also be enriched by using vermicompost or biodung compost as additional supplements.

Plant vigour can be further stimulated through bio enhancers, viz., *amrut pani*/*jeevamrut* introduced through irrigation water and foliar spray of BD/BD liquid manures.

Intercrops and crop rotation

The nutrients present in the soil get depleted when the same crop is continuously cultivated. A particular nutrient taken up largely by a single crop gets reduced/depleted from the soil. To avoid this, crop rotation should be practised. This not only helps to retain the nutrients in the soil but also improves the fertility.

Intercrops like spinach, radish, pulses and oilseeds can be grown with tomato. Cropping systems like okra-tomato, tomato-onion are popular in various parts of India. Non-solanaceous crops like rice, maize, sorghum, wheat, millets, cabbage, cauliflower, radish, watermelon, onion, garlic, groundnut, cotton, safflower, sunflower and sesame can be grown after the tomato crop. A gap of at least one year should be allowed between two solanaceous crops such as tomato, chili, brinjal, capsicum and potato.

There is a practice of growing marigold along with tomato for controlling fruit borers and mosaic disease. For every 16 rows of tomato, a single row of marigold should be sown as a trap crop. The marigold nursery should be raised 15 days before the tomato nursery. When planting is undertaken, the marigold seedlings would be 40 days old and tomato seedlings would be 25 days old. This would facilitate synchronous flowering in marigold and tomato. Marigold attracts female fruit borers. The female lays the eggs on the marigold flowers which can be manually collected and destroyed.

Training and pruning

Plants with an indeterminate habit need to be pruned to one or more stems and trained on stakes. Axillary shoots should be removed every week leaving behind well placed lateral shoots. The growing tips should be pinched off when the plants are 1.5 metres tall. This reduces the incidence of soil borne diseases and results in an early harvest with large and clean fruits.

Staking

Staking is needed for hybrids which are generally of tall stature and heavy bearers. It also makes intercultural operations easier and helps in maintaining the quality of fruit. The plants are staked 15–20 days after transplanting or when they are 15–25 cm high. Staking can be done either by using individual wooden stakes or by pulling overhead wires to which the individual plants are tied. For indeterminate types, two or three wires can be stretched parallel to each other along the crop rows and the plants tied to them.

Special techniques

Trenching to increase yield

When tomato plants fail to produce flowers and fruit, a small trench can be dug around the area to destroy the weeds. The plants can also be deprived of water and allowed to wilt for a day. Later, when the crop is irrigated, they will start to flower.

Application of tank silt

Application of tank silt @ 25 tonnes/ha to irrigated tomato supplies micronutrients that build resistance to pests and also saves expenditures on plant protection.

Prevention of flower drop

When there is excessive flower drop, a spray of neem seed and cow dung mixture can be given. To prepare this mixture, five kilograms of neem seed are ground well and diluted with water and then filtered. Twenty-five kilos of fresh cow dung are mixed thoroughly with this filtrate. The resulting product is sufficient for spraying on one hectare of land provided one adds the required quantity of water. The spray will stop flower drop.

Increasing market quality

Application of silt and red soil followed by eight tonnes of farmyard manure per hectare in two installments, (once at the time of transplantation [100 kg] and another at the time of flowering [100 kg]) to the tomato nursery controls soil borne pests and diseases. Such an application is also found to impart an attractive colour to the tomato and to result in an increase in its size.

WATER REQUIREMENTS

The crop needs careful irrigation with sufficient water at the right time. Frequent irrigation is essential for optimum growth and fruit set. It is necessary to maintain an even water supply. The crop should be irrigated at intervals of 8–12 days. In the summer, the crop needs frequent irrigation due to the high evaporation rate. The open furrow method of irrigation is widely adopted. Staked crops require water at every 5–7 days interval. A period of drought, followed by sudden irrigation, might lead to cracking of fruits. Late irrigation results in the production of watery fruits. Drip irrigation is highly economical and produces quality tomatoes.

It can also be modified by providing liquid biomanures (*amrut pani*/cow pat pit/vermi-wash/*panchagavya*, etc.) along with the

irrigation water. The method is widely used in green houses and glass houses.

Conservation techniques

Mulching with straw, saw dust and black polythene helps in moisture conservation. Mulching also helps in controlling weeds and reducing the incidence of pests and disease, thereby ensuring quality fruits.

PROBLEM INSECTS

Insects and diseases are a major threat to tomato cultivation and are responsible for a considerable loss in yields. A major part of the cultivation cost is in fact incurred for crop protection. A list of major pests and diseases affecting tomato cultivation are listed below, along with their organic management measures.

Fruit borer – *Helicoverpa armigera*

Tobacco caterpillar – *Spodoptera litura*

Serpentine leaf miner – *Liriomyza trifolii*

White fly – *Bemisia tabacci*

Root-knot nematode – *Meloidogyne spp.*

Fruit borer (*Helicoverpa armigera*)

This is a polyphagous pest infesting most cultivated crops. It is a major pest of tomato as well and is widely distributed throughout India.

Life cycle (4–6 weeks)

The adult moths are medium sized, stout and pale brown in colour with a reddish brown tinge. The forewings are olive green to pale brown in colour with a circular brown spot at the centre. The hind wings are smoky white in colour with a broad dull blackish outer border.

The eggs are ribbed, dome-shaped and yellowish white. The freshly hatched larvae are yellowish white and the fully grown caterpillars are in varied colours. They are mostly apple green with white and dark grey longitudinal lines. They have a white wavy line on the lower lateral part of the body. The eggs are laid on the leaves

and flowers. At times, they are also found on young fruits. Pupation occurs in the soil.

Damage pattern

The young larvae feed on the tender leaves. At later stages, they attack the fruits and bore circular holes. Usually the larvae thrust only their heads inside the fruits. They move from one fruit to another, causing damage. Externally, the damage appears in the form of holes. They are found from flowering to harvest stage, especially during July to November.

Economic threshold level

2 larvae / 2 m row length

Management

- Monitor top three leaves for *Helicoverpa* eggs and hand pick larvae.
- Intercropping tomato with marigold is an effective IPM practice. Planting of the trap crop should be adjusted in such a manner that tomato flowering coincides with the tight bud stage of the marigolds. Marigolds attract both fruit borer and leaf miner adults for egg laying.
- Growing sorghum (8 rows) as a border crop around the field at 30 x 10 cm spacing promotes natural predators like *Chrysoperla* and *Coccinellids*.
- Place 15–20 bird perches per hectare. This invites predatory birds.
- Spray 5% neem seed kernel extract, *Andrographis kashayam* or five leaf extract to kill larvae at their early stages.
- Soil application of the seed extracts of *Strychnos nux-vomica* @ 1.5 gm/plant at an interval of 20 days, twice, when there is severe borer attack.

Use of biocontrol agents like NPV (@ 250 LE/ha), *Bacillus thuringiensis* (@ 1 gm/litre of water), *Trichogramma chilonis* (@ 50,000 eggs/ha, six times at weekly intervals) and *Bracon hibitor* (larval parasite).

Tobacco caterpillar (*Spodoptera litura*)

This caterpillar is a major tomato pest and is widely distributed throughout the world. It is polyphagous in nature.

Life cycle (30–40 days)

The adult moths are stout and pale brown in colour. The forewings are greyish brown with white markings. The hind wings are opalescent and semi-hyaline. The caterpillars are also stout and cylindrical. When fully grown, they are 40–50 mm in length and pale brown in colour with a greenish violet tinge. They are smooth and velvety. They possess a series of sub marginal narrow yellow spots with black lunules above them. A black band is found around the body both on the anterior and posterior ends. Eggs are laid in clusters on the ventral surface of young leaves. The egg clusters are usually covered with brown hairs.

Damage pattern

Freshly hatched larvae feed gregariously, scraping the leaves from the ventral side. They feed voraciously on the leaves at night. They also feed on the fruits by making holes in them.

Management

- Plant castor @ 125 per hectare as a trap crop. Castor attracts the egg laying moths. The egg masses and larvae can be collected and destroyed.
- Pheromone traps can be installed @ 10 per hectare to monitor the pest.
- 5% neem seed kernel extract can be sprayed to kill the young larvae.

Pheromone trap placed in the field

Serpentine leaf miner (*Liriomyza trifolii*)

The leaf miner is a polyphagous pest introduced from the USA in the early nineties. It is widely distributed now in India.

Life cycle (15 days)

The adult fly is tiny with transparent wings. The female has a prominent retractile ovipositor. The maggots are legless and pale yellow in colour. Pupation occurs in the soil.

Damage pattern

The maggots damage the plant by mining into the leaf. They feed on the inner most subphyla tissues. The diameter of the serpentine mines increases as the larva grows.

Economic threshold level

Two miners per plant.

Management

- Grow one row of field bean as an intercrop after every eight rows of tomato. Field beans should be sown 10–12 days before transplanting the tomato seedlings.
- Spray 5% neem seed kernel extract or ginger, garlic, chili extract (@1 litre/tank).

White fly (*Bemisia tabaci*)

Life cycle

Both the nymphs and adults of the white fly are very sluggish and they are found clustered together on the under surface of the leaves. Nymphs are oval, scale-like and pale yellow in colour. Adults are yellow with a white waxy coating over the body. Their wings are whitish.

Damage pattern

The adults lay eggs on the under surface of the leaves. Both nymphs and adults suck the sap from the underside of the leaves and flowers. White flies are also responsible for transmitting leaf curl virus.

Economic threshold level

Two nymphs or adults per leaf

Management

- Cover the nursery bed with a 40 mesh nylon net to prevent entry of the flies.
- Sow pearl millet as a barrier crop around the main field. This should be done 15 days before transplanting the tomato.
- Install 50 yellow sticky traps/ha.
- Spray 5% neem kernel extract when the pest incidence is above ETL.

General management of insects

A decoction prepared by boiling the leaves of *Aloe vera*, neem, *Ocimum tenuiflorum*, *Achyranthes aspera* and *Aristolochia bracteata* in water can be used to prevent pest and disease attack.

This is mixed with water (@100 ml decoction per litre of water) and sprayed on the plants.

Beneficial insects

Spiders, ladybird beetles and other coccinellids.

DISEASES

Fungal diseases:

Damping off (*Pythium aphanidermatum*)

Damping off is a fungal disease found in nurseries where the seedlings are found to be overcrowded. It is commonly seen in many vegetables immediately after monsoon showers.

Symptoms

There are two different types:

Pre-emergence damping off: The young seedlings are killed even before they emerge from the soil. The fungus attacks the germinating seeds and they rot even before the hypocotyls emerge. Since this happens in the subsoil it cannot easily be spotted by the farmers who may have been misled on the quality of the seeds.

Post-emergence damping off: This phase is characterized by toppling over of infected seedlings at any time between the period that they emerge from the soil and the stage the stem hardens to resist pathogen attack. Infection affects the stem at the ground level or spreads through the roots.

The affected seedlings are pale green with a brown water soaked lesion at the base of the stem. Later, the lesion girdles the stem and spreads both upwards and downwards. The affected tissues are soft and water-soaked and they usually rot, leading to the collapse of the seedlings.

The disease starts in patches and spreads to the entire lot in the nursery in the course of 2–4 days.

Causal agent

Pythium is the most common species of fungus responsible for damping off disease in seedling nurseries. The fungus has a characteristic mycellium and reproduces both sexually and asexually. Sporangia aid in asexual reproduction. Sexual

reproduction is characterized by the formation of oogonium, antheridiums and zoospores.

Disease cycle

The pathogens are soil borne. They are week saprophytes and poor parasites. They remain in the soil as zoospores during adverse conditions and germinate when there is sufficient moisture. The zoospores germinate to produce mycellium which multiplies rapidly and infects the host tissues. The occurrence is more in heavy and compact soils that are not well drained and which do not have proper aeration. Temperatures between 27–31 °C are conducive for spread. High moisture content, close planting and poor aeration predisposes the seedlings to damping off.

Management

- Use certified seeds.
- Partial sterilisation of the soil by surface burning of a thick stack of farm trash; solarisation by covering the nursery bed with alkathene.
- Formation of raised beds with better drainage facilities.
- Application of 400 gm of neem cake per sq. m. of nursery bed 15 days before sowing, and watering at 3–5 days' interval.
- Use of light soil for nursery beds, thin planting, light and frequent irrigation and application of well decomposed manure.
- Seed treatment using leaf extract of *Bougainvillea glabra* (@ 20ml per litre of water) for six hours.

Early blight (*Alternaria solani*)

This is one of the most common diseases of the potato and is also found to attack the tomato. Since the disease appears early in the season, it is known as early blight.

Symptoms

The pathogen produces leaf spots of varying size. The spots are irregular in shape, dark brown in colour with concentric lines in the centre. In severe cases of infection, several spots coalesce to form large patches resulting in leaf blight. In advanced stages, the disease causes defoliation of plants, exposing the fruits to sun, causing sunscald. Under suitable environmental conditions the fungus can cause damping off and collar rot. Occurs at the seedling stage and with older plants.

Causal agent

The fungus produces mycellium which has both inter and intra cellular cells in the host tissues. They survive as conidia and remain viable in the soil at 0–12 cm depth for twelve months.

Disease cycle

The pathogen is air borne. The lower leaves are more susceptible than the upper ones. Infection takes place slowly and plants grown under high moisture conditions are highly susceptible.

Economic injury level

One diseased leaf for every four healthy leaves or 25% damage

Management

- Crop rotation with a non-solanaceous crop.
- Do not grow tomato in soils where potato was intensively cultivated.
- Remove infected plant parts such as branches, leaves, buds, and burn them.
- Destruction of collateral host is desirable.
- Spray 5% eucalyptus or lantana leaf extract in the evening.
- Diluted cow dung can be applied to the root zone of the affected plants.
- Treatment with *Trichoderma viride* or *Pseudomonas fluorescens* @ 5 gm/100 gm of seeds.

Late blight *(Phytophthora infestans)*

Late blight is a very serious disease of the potato which also attacks the tomato. The disease was introduced from Europe to India between 1870 and 1880. In hilly areas the disease first attacks the tomato and then spreads to the potato. The fungus attacks any aerial part of the plant.

Symptoms

The disease appears on the foliage as water soaked light brown lesions. Under favourable climatic conditions (humid and cloudy weather), the lesion spreads to the entire leaf and petiole causing brown dead spots. The entire leaf may be killed in 1–4 days, if the weather is moist. Under dry weather conditions, the spots remain restricted in size and the dead areas appear hard and break away easily from the rest of the lamina. Whitish growth of fungus can be seen on the lower surface on close examination of infected leaves. Severely diseased plants wilt in a few days causing severe loss in crop yield. Dark olive greasy spots are found on the fruits and the tissues remain firm. Blight is followed by soft rot due to invasion by secondary pathogens.

Causal agent

The fungus produces zoospores under advanced conditions. They spread both inter and intra cellular-wise in the host, producing free branching hyphae.

Disease cycle

Sufficient soil moisture and suitable temperature favourthe the germination of sporangia. They spread through diseased seedlings and fruits.

Management

Five kilos of wood ash should be mixed with 50 litres of water and kept aside for two hours. The extract should then be strained and used as a spray to control late blight. Dried powdered ash can also be applied to the crops.

Fusariam wilt
(Fusarium oxysporum f. lycopersici)

This is a very serious vascular disease of the tomato common in temperate regions. It also occurs in warmer areas.

Symptoms

Fusarium wilt causes clearing of vein lets, chlorosis of leaves and drooping of petioles. The young leaves die in succession and later the entire plant will wilt and perish in a few days. The symptoms may appear only on a few branches. Dark brown or black discolouration of vascular tissues may be seen in the roots or basal portion of the stem when the disease is in an advanced stage of infection. The plants remain stunted due to the pathogen attacking the roots. Under humid conditions, pinkish fungal growth can be seen on the dead plants.

Causal agent

The fungus produces both macro conidia and micro conidia. Fungal hyphae spread both inter and intra cellular in the host tissues.

Disease cycle

The disease is soil borne and the pathogen is present as a saprophytic ally in the soil for several years. A temperature of around 28 °C is optimum for development of the disease. The disease is more severe at a pH less than 6.4 and greater than 7. Short day length, low light intensity, low nitrogen and phosphorus and high potassium predispose the plants to the disease. The fungus multiplies rapidly within the host tissue, clogs the vascular tissues and interferes with the transportation of water and nutrients upwards thereby resulting in the wilting of the plants. A few research reports also suggest that wilting is caused by the toxins produced by the fungus.

Management

- Crop rotation with non-*solanaceous* crops reduces inoculums in the soil.

- Seedling root dip in a solution containing ten grams each of turmeric and asafetida dissolved in a litre of water is preferred before transplanting.
- Keep the fruits away from the soil by proper training and pruning.
- Pull out the affected plants and destroy them.
- Use varieties like Mar globe, Kanora, Sioux and Roma which are resistant.
- Spray fifteen days' old panchagavya, diluted with ten parts of water.

Fruit rot

Tomato fruit rot

Phytophthora infestans, *P. palmivora* and *P. parasita* are associated with fruit or stem rot of tomato plants in India. This disease occurs under humid weather conditions. The other species of fungi causing fruit rot both in the field and in storage are *Fusarium sp.*, *Alternaria solani*, *Rhizopus sp.* and *Erwinia sp.* The extent of damage depends on climatic conditions, cultivation methods and handling in transit and storage. Good phytosanitary measures can reduce attacks by these fungal pathogens.

Root and collar rot

Caused by *Fusarium solani*, *Sclerotium rolfsii*, *Rhizoctonia solani* and *Macrophomina phaseolina*. These are soil borne pathogens also found in crop debris. They can be controlled by uprooting the diseased plants along with the infested soil and burning them.

Anthracnose / Ripe fruit rot (*Colletotrichum phomoides*)

The pathogen is soil borne. Infected ripe tomato fruits show small, water soaked, sunken, circular spots. They may increase in size up to 1.2 cm in diameter. As it ages, the centre of an older spot becomes blackish and emits gelatinous pink spore masses.

The anthracnose lesions easily attract other rotting organisms which now completely rot the infected fruit.

Infection may also occur on unripe fruits, stems, leaves, and roots. Infected unripe fruits do not show symptoms until ripening. The fruits undergo a semi-soft decay.

Infected roots, called black dot root rot, become evident only when the fruits begin to ripen. The root lesions become brown and are dotted with fruiting bodies. The outer layer of the infected roots is completely rotten.

Powdery mildew (*Leveillula taurica* and *Erysiphe polygoni*)

This is a minor fungal disease in which a white powdery growth of the fungus is seen on the leaves.

Management

- Spray a mixture of milk and water in equal quantities every three to four days at the first sign of mildew symptoms.

Bacterial diseases:

In nature, bacterial canker is found only in tomato.

Bacterial canker (*Clavibacter michiganense*)

Symptoms

The bacterium affects the various plant parts that are above the ground. Wilting of leaves and drooping of petioles is observed. Light brown streaks appear on the stem and the petiole later turns black and cankerous. Small, water soaked lesions are seen on the fruits. These turn dark brown, corky and cankerous later.

Causal agent

These are gram positive, non-motile strains of bacteria, which prefer a temperature of 24–27 °C.

Disease cycle

The pathogen is both seed borne and soil borne. Seeds may be the primary source of infection, and soil the secondary source.

Management

- Crop rotation – avoid growing *solanaceous* crops in sequence.

- Hot water treatment of seeds is desirable.
- Spray cow dung extract.

Bacterial leaf spot (*Xanthomonas campestris PV. Vesicatoria*)

Occurs during the vegetative and fruiting stage.

Symptoms

Leaf spots are small and translucent in the beginning. Later, they enlarge to circular, brown to black greasy spots surrounded with a yellowish halo. Stem lesions are black and canker-like and the fruit lesions are corky.

Bacterial wilt (*Pseudomonas solanacearum*)

This is a deadly disease of tomato. Cultivation of the crop has been abandoned in some parts of the country due to the disease.

Symptoms

Wilting, stunting, yellowing of foliage and a severe case of infection leads to death of the plant. The lower leaves droop before wilting occurs. The vascular system becomes brown. If a segment of a lower stem is cut, it yields bacterial ooze.

Causal agent

The pathogen is soil borne and can persist for long periods.

Management

- Crop rotation with cruciferous vegetables, field bean, maize or soybean
- Seedling root dip in asafoetida solution (@ 10g/litre of water)

Viral diseases:

Tomato mosaic

Tomato mosaic disease is caused by different strains of virus such as tobacco mosaic virus (TMV), cucumber mosaic virus (CMV), potato virus Y and X.

Symptoms

The leaves show light and dark green mosaic symptoms. There is uneven growth of the light and dark green portions. As a result, the normal green patches tend to appear sunken, giving a rough appearance to the leaves. In certain cases, downward curling of the

leaves is also seen. In advanced stages, necrosis of the stem, petioles, leaves and fruit is observed.

Management

- Powder neem cake or mustard oil cake, mix it with water and apply near the root region.
- Spray asafoetida solution (@ 10 gm/litre of water).
- Spray milk on green house tomatoes to reduce TMV infection.

Spotted wilt virus

Vector – *Thrips tabaci, Frankliniella insularis, F. occidentalis*

Symptoms

Bronzing of the upper surface of young leaves which extends from leaf blade to petiole and stem, causing upward rolling of leaves. Yellow spots are seen on the fruits.

Leaf curl (caused by Gemini virus)

Vector – *Bemisia tabaci*

Symptoms

The virus causes dwarfing, puckering, severe curling and mottling of the leaves. Downward rolling, crinkling, chlorosis of newly formed leaves and excessive branching are observed and the plants become completely sterile. Association of leaf curl with root knot causes more damage. Occurs during summer (February–June) from seedling to harvest stage.

Economic injury level

Two white flies per leaf or three infected leaves per plant.

Management of viral diseases

- Crop rotation
- Use of virus free seedlings
- Soil sterilisation
- Removal and destruction of diseased plants
- Spraying 5% NSKE or neem leaf extract to control the white fly vector.

Big bud of tomato

This is on MLO (mycoplasma-like organism) disease transmitted by leafhoppers. The pathogen can survive on alternate hosts like *Solanum nigrum*.

Management

- Removal and destruction of diseased plants
- Destruction of *solanaceous* weeds

Root knot nematode (*Meloidogyne incognita, M. javanica*)

Disease incidence is widespread in the summer and in the spring in north India. Root knot or root galls caused by nematodes are a common disease of many vegetables in tropical and subtropical climates. The infection weakens the plants and pre-disposes them to invasion of many root rot and wilt causing fungi and bacteria, thus compounding the damage.

Symptoms

The plants remain pale and stunted and pod set is extremely low. The leaves are yellowish green or yellow in colour. Drooping and sudden wilting of leaves is observed. So is scorching from the margins inward. Formation of knots or galls in the root system is a characteristic symptom. Maximum number of galls per plant and number of egg masses per gram of root occur when the plants are infected at two-week stage. The main root and the laterals have spherical or elongated galls of various sizes. In advanced stages of infection, these tissues decay and are attacked by other pathogenic and saprophytic organisms. Cultivars like Long Green Smooth, IC-9273 and IC-18960 are reported to be resistant to root knot nematodes.

Causal agent

Meloidogyne incognita is abundant in cooler and warmer areas whereas *M. javanica* is common in warmer areas. The nematodes are sedentary endoparasites of roots. The female lays eggs in the host root tissues in masses or egg sacs. The eggs are dormant and do

not hatch immediately. An average of about 400–500 eggs are found in a single egg mass. The eggs hatch under suitable environmental conditions. Newly hatched larvae are small, slender and about 0.3–0.5 mm in length. Their movement in the soil is slow and, on contact with host roots, the larvae enter just above the root cap. Upon entering the roots, the larvae move between the undifferentiated cells and reach the endodermis where they become sedentary. They eject secretions while they feed on the cells which cause enlargement of cells or formation of galls.

It is very difficult to control nematodes in an infested field since the eggs survive in the soil protected by host tissues. Nematodes are introduced through infected seedlings and shifting soil from neighbouring infested fields.

Management

- Summer ploughing
- Crop rotation – in the case of cereals, there is a definite reduction in the population.
- Seed treatment should be carried out with 50 gm *Trichoderma viride*/*Pseudomonas fluorescens*.
- Sow seeds thinly, leaving one inch spacing between the rows.
- Intercrop tomato with marigold.
- Apply neem cake in the main field @ 500 kg/ha or 400 gm/sq. m. in the nursery.
- Attempt soil solarisation before sowing. Cover the nursery beds with 1 mm thick black polythene sheets for 48 hours to kill nematodes and weed seeds.
- Fungal species such as *Paecilomyces lilacinus*, *Verticillium* and the *bacterium Bacillus penetrans* can be used as bio-control agents.

General management for diseases

- Crop rotation with corn, cereals and sorghum is preferred as most of the vegetables are susceptible to many of the above pathogens.
- Application of composted urban organic waste for tomato and cabbage reduces plant susceptibility to disease.
- Rouge out affected plants and spray 5% NSKE when the disease appears.
- Minimise unnecessary movement in the field to avoid mechanical injury to the plants causing spread of TMV.
- Carry out field sanitation by burning infected crop debris and residues at the end of each cropping season.
- Application of the residual waste obtained during the preparation of country wine in the seed beds before sowing makes the soil soft and is claimed to help the seedlings grow faster and impart resistance against disease.

Non-parasitic diseases: Physiological disorders

Blossom-end rot

This disorder is caused due to the deficiency of calcium in the developing fruits. Other factors like extreme moisture fluctuations, root pruning and excessive nitrogen fertilisation can also result in blossom end rot. The symptoms may appear on the fruits at any time during their development but they normally appear when the fruits are half grown.

Symptoms

Light brown, water-soaked lesions appear on the blossom end of the fruits. These spots later enlarge and turn black. Secondary infection is caused by other pathogens causing decay through these spots. The affected fruits ripen much faster than the normal fruits.

Management

- Application of excessive nitrogen particularly in ammonium form should be avoided.

- Application of calcium.

Cat face

This disorder also starts from the blossom end as malformation and scarring of fruits. Factors like extreme heat, drought, low temperature and contact with hormone-type herbicide sprays causing injury to flowers favour this disorder. Affected fruits are puckered with swollen protuberances and can have cavities extending deep into the flesh. Generally, any disturbance to flowers can lead to abnormally shaped fruits.

Management

- Planting less susceptible tomato varieties.
- Keeping herbicides away from flowers

Puffiness

The affected fruits are bloated and angular. Cross section of the fruit shows cavities that lack the normal gel. Puffiness may result due to incomplete pollination, fertilisation or seed development. Cool temperatures normally have a negative impact on fertilisation. High nitrogen and low potassium content can also lead to puffiness. Certain tomato cultivars are more susceptible to this disorder.

Sun scald

The near maturing fruits when exposed to sun are prone to scald. On the exposure of tomato to high temperature (40 ^{0}C) and intense sun light, whitish grayish and papery lesions develop. These occur during summer or late winter when the foliage is sparse due to which the fruits are exposed to dry wind and direct sunlight.

Symptoms

Green unripe fruits develop blotches of dry skin on the exposed surface. Initially, the dry area is white in colour and later turns brown. This portion may serve as the entry point for several bacterial and fungal diseases. The internal tissues have a blistered, water-soaked appearance. Rapid desiccation or loss of moisture

produces sunken areas on the fruit which are white or grey in colour in the green fruits and yellowish in red fruits.

Defoliation of the plants due to any external or internal factor, such as disease, etc., will expose the fruits to sunlight, thereby increasing the chances for sun scald.

Management

- A proper disease control programme to prevent defoliation.
- Covering exposed fruits with straw.

Fruit cracking

Factors like heavy showers coupled with high temperatures following a period of drought result in fruit cracking. This condition is common during the rainy seasons and causes extremely rapid growth of fruits.

Symptoms

The initial symptoms are seen from the stem end as cracks of varying depth. These blemishes on the fruit provide entry to many fungal pathogens causing decay. Radial cracking is more likely to develop in fully ripe fruits than in mature green ones. Fruits that are more exposed to sun develop more concentric cracking than those which are covered with foliage.

Nutritional disorders

The deficiency symptoms of a few important nutrients are given below:

Nitrogen

The growth of plants is affected and the leaves remain small and yellowish. The veins appear red in colour due to accumulation of excess anthocyanin in the stem. Stems are thick and hard, flower buds turn yellow and drop off. Fruits are small and pale green before ripening. Excess nitrogen favours vegetative growth and affects fruit setting. The fruits produced tend to be puffy.

Phosphorus

Common in very light soils. Growth is affected and maturity is delayed leading to reddening of stem and leaves which later turn reddish purple.

In case of acute deficiency, small sunken areas showing concentric rings develop on the leaves.

Potassium

Light soils are deficient in potassium. Leaves turn dark green, with short internodes. Margins of newly formed leaves become finely rogues and that of old leaves turn grey. Later the margins turn brown and necrotic. The lamina in between the veins appear pale which leads to the production of blotchy fruits that drop off soon after ripening. Ripening is uneven.

Sulphur

The stem becomes elongated, hard and woody and the lower leaves turn yellow.

Magnesium

Present in light soil or when there is excess calcium in the soil. First symptoms appear on the older leaves. Inter veinal chlorosis. Lower leaves turn brittle.

Iron

Present in highly calcareous soils. Chlorosis of leaves. Pale yellow mottling starts at the base of the leaves and spreads upwards.

Copper

Deficiency normally occurs in humus rich soils. Plant growth is retarded and the leaves are bluish green with small and wrinkled leaflets.

Zinc

Frequent in calcareous and alkaline soils. Yellowing, puckering and necrosis of leaves. In small quantities zinc helps in increasing the carbohydrate and vitamin C content of fruits. Reported to shorten the period of maturation.

Manganese

Severe inter veinal chlorosis of leaves and dwarfing of plants.

HARVESTING

Time of harvest

Picking of fruits from the plants depends mainly on the purpose for which they are grown and the distances through which they are to be transported. The different stages at which the tomato is harvested are immature green, mature green, turning pink, half ripe, red ripe and over ripe.

Mature green fruits are those which have not begun to turn pink.

Turning pink means shows some pink colour at the blossom end.

Half ripe fruits show pink colour over most or the entire surface.

Ripe or red ripe fruits are those which have developed full colour and are firm.

Generally, firm mature green fruits are best suited for shipping or distant marketing. For fresh consumption, tomatoes are harvested at the turning pink or half ripe stage. For seed production, red ripe tomatoes are ideal. Fruits for canning or juice extraction are harvested when they reach the red ripe stage and processed soon thereafter.

Tomatoes are harvested twice a week when the plants are about three months old. Fruiting may continue for a period of 1–2 months based on the cultivar, soil and climatic conditions. Tomatoes ripen on the plant itself; however, ripening may take place after harvesting as well. For artificial ripening, the fruits are harvested at the mature green stage or at the turning pink stage and kept under room temperature (15–25 °C). Harvested fruits produce

adequate quantities of ethylene, the release of which aids in the ripening process. Fruits which ripen on the plant are superior in vitamin C content when compared with artificially ripened ones.

POST HARVEST TECHNIQUES

Grading

Damaged, rotten and cracked fruit are removed. Healthy, attractive, clean and bright fruits are preferred. The grades are based on the appearance and quality of the fruits and not specifically on their size. Grading based on size is done mostly by retailers for the local market: the fruits are graded as small (<100 gm), medium (100–255 gm) and large (> 255 gm). Urban markets have differential pricing based on size grades. The Bureau of Indian Standards (BIS) has specified four tomato grades, viz., 'super A,' 'super,' 'fancy' and 'commercial.'

Packing

Wooden boxes, crates, polythene bags or baskets can be used for packing tomatoes. For local markets, the fruits are packed in bamboo baskets or plastic crates. Plastic crates are more convenient for handling since they can be stacked one above the other. The contoured rim keeps the product safe and allows sufficient air circulation. The packing should be rigid enough to protect the fruits from being crushed. For export, the fruits are packed in cardboard boxes of 15 kg capacity. Size graded tomatoes are packed in layers in such boxes in order to make the best use of the box.

STORAGE

Tomato producers in India lose about 20–30 percent of their crop in post harvest spoilage. The main objective of storage is to extend the shelf life of the produce by controlling the rate of ripening. High temperature, humidity and oxygen reduce the shelf life of the fruit and bring about spoilage. Temperature between 12–15 °C is ideal for storage. The ideal storage temperatures differ depending on the maturity of the fruit. A temperature of 13 °C and 90–95% relative humidity is recommended to slow down ripening. At this temperature, most varieties keep in good condition for about 2–3

weeks and the colour change is very gradual. Unripe tomatoes can be stored for 4 weeks at a temperature of 8–10 °C and 85–90% relative humidity. Fully ripe fruits can be stored for about a week at 7 °C and 90% relative humidity. Below this temperature, the fruits show symptoms of cold injury. Atmospheric storage conditions with 5% carbon dioxide and 2.5% oxygen are best. The recommended relative humidity is 85–90%.

Traditional storage techniques

Tomatoes can be stored in baskets in which the fruits are piled with alternate layers of charcoal and left undisturbed for six months. They will be fully ripe but still fit to eat.

Plants with unripe tomatoes can be hung in a shady place upside down and they will keep fresh thus for up to three months. The compound responsible for ripening is supposed to move more slowly when tomatoes are inverted.

Some farmers preserve tomatoes by keeping them in a cool sand bed. They can thus delay selling the tomatoes by 30–45 days and get a better price for them.

Usage

Fresh fruits are consumed raw as salads or after cooking whereas unripe fruits are cooked before consumption. Fully ripe fruits are also used for canning in large quantities. The fruits are also consumed in the form of juice. The other products of commercial value made out of tomato are puree, paste, ketchup, sauce and soup.

Other uses

Tomatoes can also be used to boost the growth of paddy seedlings. The tomatoes are first dried in sunlight; the seeds are then extracted and powdered. Fifty-five grams of the seed powder are mixed with a sticker solution and sprayed over the paddy seedlings in the nursery 14 and 21 days after sowing to boost seedling growth. For spraying one hectare of paddy, 500 gm of tomato powder mixed with 100 ml of sticker solution is sprayed 14 and 28 days after transplantation.

Tomato nursery

Transport

The fruits are highly perishable in nature and hence need to be transported at the earliest. Tomatoes are transported by road through tractors, trucks and also by rail and air to distant markets. Village produce is transported to the nearby towns and city markets only by road. Maintenance of a cold chain is essential during transport of export produce.

ORGANIC TOMATO CULTIVATION

Case study

Mr. Gummireddy, a farmer from Hosur, produces tomato seedlings for commercial sale by mulching and the use of a netlon shade net. The crop is produced in two stages – sowing stage (0–8 days) and hardening stage (8–27 days). In the sowing stage, the seeds are grown completely under mulch for 5–8 days. In the hardening stage, the seedlings are grown under the netlon shade net up to 27 days. Mr. Gummireddy also exports the seedlings, using protrays.

Address: Mr. Gummireddy, A. Chettipalli, Matthagiri post, Hosur district.

ORGANIC INPUTS

This chapter outlines various inputs for nutrient, pest and disease management commonly used in the organic farming of crops such as rice, groundnut, tomato and okra. The method of preparation and application is briefly described. For more detailed information, please consult the companion FAO publication, *Current State of Inputs for Organic Agriculture.*

NUTRIENT MANAGEMENT

Nutrients for organic farming can be managed in a number of ways in an integrated manner. Composting is the most important and widely used option. Various other methods include the use of green manure crops, crop rotations, crop residue, mulching and biofertilisers.

COMPOSTING

Composting is a process by which organic wastes are converted into organic fertiliser by means of biological activity under controlled conditions.

Land selection for compost making

The land selected should not be low-lying or waterlogged.

Upland or an elevated land that has shade is ideal for compost preparation.

The soil should not be sandy.

The soil in which compost is to be prepared should not be penetrated by roots of trees.

Materials to be avoided: Plastic products, polythene covers, bones of cattle, stones, thick stems of plants and glass bottle pieces.

Different types of compost

There are various popular methods of composting and notable amongst these are the following:

Aerobic composting

NADEP composting

Cycle method of composting

Vermicomposting

Biodynamic composting

Aerobic composting

Usually compost is best made by spreading the biomass in layers using alternative layers of material rich in nitrogen – for example, fresh green grass, leaves and shoots of leguminous trees such as subabul (*Leucaena leucocephala*), glyricidia (*Glyricidia maculeata*), *daincha* (*Sesbania aculiata*), sunhemp (*Crotolaria juncea*) etc.) and carbon – for example, paddy straw, hay, wood chips, dry leaves, grasses, coir pith, coconut fronds etc. In this way, the green material provides the nitrogen that the bacteria requires for their growth in order to break down the carbon material. A general recommendation is to make every layer of nitrogen rich materials six inches high and of carbon rich materials, four inches high. Besides maintaining a balanced proportion of 60 and 40 percent respectively, layering also improves air circulation within the heap. If animal dung is in short supply, it can be made into a slurry and sprinkled on each layer of carbonaceous material to work as a starter mixture. Care must be taken to keep the dry carbon material moist. Generally, it is advisable to wet the dry materials before they are added to the heap. A simple test to assess proper moisture content is that no water should drip out of the material when it is squeezed by the hand.

NADEP composting

A brick structure measuring 10' x 6' x 3' is prepared – with holes in the side walls to ensure adequate supply of air during composting. The brick tank is filled with farm wastes, soil and cow dung and water is added to maintain moisture between 60–75%. The tank is filled with soil (16–18 qtls), farm wastes (14–16 qtls) and cow dung (1–1.2 qtls). Water is added to moisten the material and the upper layer is plastered with the soil and dung mixture.

After 75–90 days of composting, a microbial culture of azotobacter, *rhizobium* and phosphate solubilizing bacteria is added to the mixture.

Compost becomes ready for use within 110–120 days. One tank provides about 2.5–2.7 tonnes of compost sufficient for one hectare of land.

Cycle method of composting

This method of composting requires three pits of 1 x 1 x 1 m length, breadth and height with a spacing of 0.3 m in between them.

Fill the first pit with all kinds of kitchen waste, farm waste, litter and cow dung. A few days later, transfer the decayed contents from the first pit to the second pit. Now, the first pit should be filled with fresh waste. When this gets decayed, the contents in the second pit should be shifted to the third pit and the second pit should be filled with the contents of the first pit. This process should be continued till the third pit gets completely filled. The compost in the third pit can be used ten days after it is filled.

Vermicomposting

Vermicomposting is a method of converting wastes into compost through the use of earthworms. The compost produced by this method is superior to other composts. Depending upon the number of earthworms used, the time required for composting can also be considerably reduced. Large quantities of waste can be composted by this method – i.e., about 4–5 kg of wastes can be composted by 1000 worms (approximately 1 kg) in a day. The commonly used earthworms are *Eudrillus sp.*, *Perionyx sp.*, *Eisenia sp.* Any locally available surface feeding (*epigeic*) earthworms can also be collected from the nearby soil and used for the purpose.

For setting up a compost pit, dig a pit of size 2 m x 1 m x 1m – the length and breadth can be adjusted according to the requirement. Fill the basal 0.15 m of the vermibed with broken

bricks or pebbles. This is to avoid excessive water logging in the pit. Follow this with a layer of coarse sand to a thickness of 0.05 m to ensure proper drainage. This is followed by a 0.15 m moist layer of loamy soil. Into this soil, inoculate about 3000 locally collected earthworms. Scatter small lumps of cattle dung (fresh or dry) over the soil. The dung serves as food for the worms in their early stages. Cover this with dried leaves or hay up to 0.05 m. Sprinkle water and keep the entire setup moist. Keep the unit covered with coconut fronds. Spread organic refuse from the thirty-first day on the bed after removing the fronds. The spread should not exceed 0.05 m in thickness for each application. This can be done twice a week. After a few applications, turn over the refuse without disturbing the bed. When enough refuse has been added into the unit, keep it moist and 45 days later the compost is ready for harvest.

The base of the tank should have a slight slope directed towards two drainage holes. Composting can be done in pits, concrete tanks, well rings, wooden or plastic crates appropriate for a given situation. In places where worm predators like rats, lizards, pigs are a major problem, the tanks should be covered with wire mesh to protect the worms.

Vermiwash

Vermiwash is made from earthworms reared in earthen pots or plastic drums. Secretions from the ducts of earthworms are a rich source of nutrients, vitamins, gibberellins, etc. In a big earthen pot or plastic drum (200 lit.) make a tiny hole and place a layer (5 cm) each of small stones and red sand at the bottom for effective drainage. Fill the container with 30–40 cm layer of kitchen waste or one week old dung and release 200–300 earthworms into the pot. After two weeks of earthworm inoculation, arrange water to be poured into the pot in such a manner that it drips out from the bottom in the form of drops. This extract is called vermiwash and it

is generally used as a foliar spray, after dilution with water in a 1 : 5 ratio.

Biodynamic composting

Biodynamic (BD) composting is a very unique method of converting wastes into a humus-like mass. This method comprises the use of special herbal homeopathic preparations (BD preps 502–506). These preparations enhance the composting process and in turn enrich it with nutrients. The composting period may vary from three to four months. BD preps are made and marketed by several companies in the country and together with the preps, detailed instructions are provided for their use in composting and other farm operations. More details on BD composting are available in the *Current State of Inputs for Organic Agriculture.*

Compost enrichment

It is a common practice to add minerals and microorganisms during the composting process, depending on the need. For enriching compost with phosphorous, use of rock phosphate is recommended. For calcium, lime is added. These are mixed with soil, FYM and cow dung slurry in water and spread over layers while preparing the heap for composting. Use of phosphate solubilising microorganisms (PSM) is highly beneficial at the time of composting. Other ingredients that could be added to compost heaps are non-edible oil cakes. They can be used directly as manure or incorporated in the composting process so that they are well mixed and the enriched compost is available to meet the nutrient requirement of the crops.

Mulching

Mulching is one of the simplest and most beneficial practices that can be used in organic farming. Mulch is simply a protective layer of a material that is spread on the top of the soil. It could comprise of grass clippings, wheat or paddy straw, rice husk, saw dust, coir pith, banana leaves or any other crop residues. Mulching increases infiltration of water, improves soil and moisture conservation,

regulates and moderates soil temperature, improves root growth and over time, enhances the water holding capacity of the soil and enriches it with organic matter. General guidelines are that weeds should be first uprooted from the soil (if they have no seeds or vegetative propagating parts, they should be used for mulching too) and that the soil should be moist at the time of spreading the mulch.

Green manuring

A variety of crops are used by farmers in different regions for the purpose of green manuring. In this practice, farmers sow a crop and allow it to grow to a certain stage before they plough it back into the field. Preferably, the time gap between ploughing the green manure and sowing the next crop should not be longer than 2–3 weeks so as to prevent nutrient losses from the decomposing green manure. This procedure increases the nutrient content of the soil while ensuring control of weeds. Common crops used for green manuring are sunhemp (*Crotolaria juncea*), *daincha* (*Sesbania aculeata*), horse gram (*Dolichos biflorus*), green gram (*Vinga radiata*), cowpea (*Vinga anguiculata*), black gram (*Vinga mungo*), cluster bean (*Cyamopsis tetragonaloba*), berseem (*Trifolium alexandrium*), pea (*Pisum sativum*), moth bean (*Vinga aconitifolia*), lupin (*Lupinus sativus*), *gliricidia sp.*, etc. In general, these incorporate 8–30 tonnes of biomass and 38–135 kg N/ha. In many places, application of thick green leaves is also a practice under green manuring. The leaves of mango, jackfruit, cashew, etc. are preferred as they have long lasting residual effects.

BIOFERTILISERS

The use of biological nitrogen fixation and phosphorous solubilising/mobilising microorganisms is found extremely effective in organic farming. Commonly used organisms are:

Rhizobium – Recommended for leguminous pulses and oilseed

Azotobacter and azospirillum – Recommended for cereals, vegetables, etc.

Blue green algae and azolla – Recommended for rice

Phosphorous solubiliser (*bacillus, pseudomonas*)

Azospirillum

Azospirillum is a type of bacteria that grows around the roots of cereal plants and grasses. It is capable of absorbing atmospheric nitrogen and converting it into a form that can be utilised by plants. Since it grows in the root regions, it helps the plant to absorb the nitrogen from the soil. It works effectively in those soils where the phosphorus content is less. Studies indicate that azospirillum can fix 50–200 gm of nitrogen per day in paddy.

Advantages of using azospirillum

Azospirillum fixes atmospheric nitrogen in the root regions of crops thereby enabling its easy assimilation. This enables the plant to grow well. The cost of adding nitrogen fertilisers for one acre of land is reduced by 10%. Azospirillum produces plant growth hormones in the root region thereby increasing plant growth, the number of tillers, grains and straw yield.

Azotobacter

Azotobacter is a kind of bacteria that grows around the roots of the plants and utilizes the carbon present in the soil. It is also capable of absorbing atmospheric nitrogen and converting it into a form that can be utilised by the plants. The bacterium is affected by high acidity, high salt content and high temperature. It grows well in waterlogged paddy fields.

Phosphobacteria

This is a type of bacteria that is capable of growing around the root surface of the plant. The growth of the microorganism helps in conversion of insoluble phosphate (a source of phosphorus) into a soluble form. Thus it aids in the absorption of phosphorus by plants.

Method of application

For every hectare of crop, two kilo of azospirillum or azotobacter and two kilo of phosphobacteria should be mixed with 25 kg of well decayed manure or wet sand and applied before transplanting. This helps to increase the population of these microorganisms in the soil.

Advantages of using phosphobacteria

- Phosphobacteria convert insoluble phosphates into a soluble form that can be absorbed by plants.
- Yield of plants is increased by 10–20% in all crops.
- The bacteria help in the flowering and development of earheads and roots.
- They also help in nitrogen fixation.

Algae

Growing algae along with paddy supplies the crop with the required nitrogen and phosphorus. Azolla or blue green algae should be strewn in the field 5–10 days after transplantion of paddy. The field should be drained twenty-five days and 45–50 days after strewing and the algae should be stamped into the soil.

Azolla

A floating fern that grows in the stagnant water of rice fields. This plant hosts algae called *anabaena azollae* in the cavities of its tiny fronds. It provides the necessary nutrients and space required for the growth of these algae. In turn, the algae provide the azolla fern with fixed atmospheric nitrogen and other nutrients essential for its growth. Azolla grows well in marshy land where paddy is cultivated. It is capable of providing 40–60 kg of nitrogen per hectare.

Method of application

Five to seven kilos of azolla are required per hectare of land. First, the water should be allowed to stagnate in the land that is to be cultivated. Then azolla should be sown. After one week, these plants are stamped into the soil before transplanting is done. It

degrades in about 7–10 days and thereby provides nitrogen to the rice crop.

Growing azolla along with paddy

After ten days of planting, azolla should be strewn in the rice fields. It grows along with rice as an intercrop. It grows well in about 25 days and spreads uniformly over the field. Then the water in the field is allowed to drain and azolla is stamped beneath the soil. Once again, azolla resumes profuse growth. This is again stamped at the time of the second weeding. Burying azolla beneath the soil once helps in fixing 15–20 kg of nitrogen.

Advantages of using azolla

- It provides nitrogen to the crops.
- By growing it along with the paddy crop, weeds can be eliminated.
- Use of azolla as a green manure is equivalent to the use of ammonium sulphate fertiliser.

Blue green algae

BGA are a type of photosynthetic cyanobacteria that belong to the plant kingdom. They are found in paddy fields where good sunlight, water, high temperature and high nutrients are found. They fix atmospheric nitrogen and can be seen floating as dense mats in a filamentous form on the water surface in paddy fields. BGA grows well in clayey and alluvial soil.

Method of application

BGA are added to the soil within ten days of transplanting at the rate of 10 kg/ha. They are available as small bits in plastic packets. This should be powdered and directly added to the soil. Water should be allowed to stagnate to a depth of 3–5 cms in fields where algae are grown. Blue green algae should be added to the field continuously for four cropping seasons. Thereafter, it grows naturally in the soil and produces the desired results.

Advantages of using blue green algae

- Crops obtain 60% nitrogen content by the use of blue green algae.
- The algal filaments decompose in the fields and increase the humus content of the soil.
- BGA dissolve phosphorus and make it available to the crop.
- They also dissolve iron and sulphur salts stagnating in the soil, thereby increasing soil fertility.
- BGA also enhances the chemical properties of the soil.
- Plant growth hormones produced by BGA increase plant growth.

PROBLEM INSECTS AND DISEASE

A number of options such as crop rotation, summer ploughing, solarisation, inclusion of cover, companion, inter, green manure, trap crops, use of local seeds/varieties, pheromone traps, predators, parasites, botanicals, biopesticides are available for need based management of pests and plant disease.`

Cultural methods

Adjust the time of sowing to modulate growth of the crop. Plant to plant and row-to-row spacing is similarly used to alter the microclimate and reduce risks. There are no standard prescriptions for these and are generally based on the knowledge and experience of the farming community.

Crop rotation

Rotating the crop belonging to one family with one of a different family helps to reduce pests and weed to a large extent.

Trap crops

Pests are strongly attracted by certain plants and when these are sown in a field or along the border, tend to gather in them, enabling their easy collection and destruction. African marigold, mustard, maize, etc., can be grown as trap crops in cole crops, cotton and vegetables.

Intercropping

Intercropping generally has a positive effect in terms of reducing the occurrence of pests. Insects find it difficult to locate host plants as the visual and chemical stimuli from the hosts are not strong and the aromatic odour of other plants can disrupt host finding behavior.

Use of resistant/tolerant varieties

Genotypes showing tolerance or resistance to pest and disease are preferred in organic cultivation. A series of resistant varieties of different crops have been developed in recent years for most climatic conditions.

Summer ploughing

Summer ploughing is an important cultural practice for pest control. When the land is ploughed, the inactive stages of pests like egg masses, larvae and pupae present within 5–10 cms surface of the soil get exposed. They are killed due to the intense heat of summer and are also eaten away by predatory birds.

Keeping bunds clean

Field and field bunds are the favourite egg laying spots of most pests. Hence, wild grasses and weeds found in the field and on the bunds should be periodically removed.

Plastering of bunds

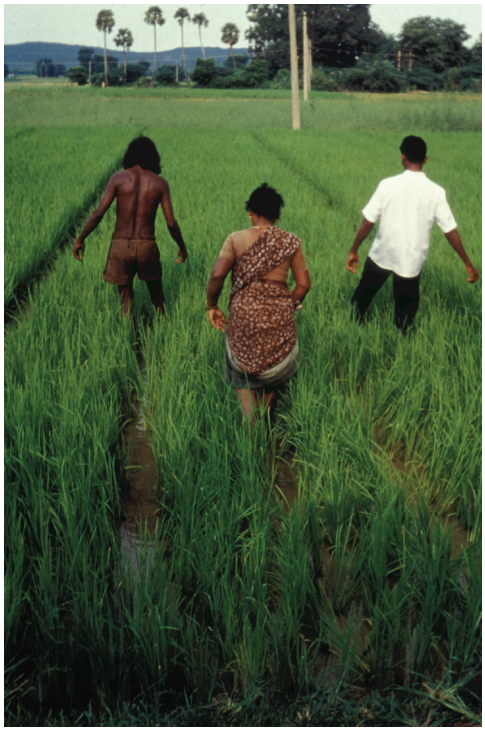
Weeds found on the bunds should be removed and the bunds should be plastered. By doing this, rat holes found near the bunds can be sealed and rodent damage controlled. Such a procedure also prevents water leakage.

Proper spacing among the seedlings

When paddy seedlings are transplanted to the main field, they should be laid out with proper spacing. For short duration varieties, the inter row spacing should be 5 cm and inter hill spacing should be 10 cm. For medium duration varieties, it should be 20 cm x 10 cm and for long duration varieties, 20 cm x 15 cm. This facilitates penetration of sunlight to the lower portions of the crop and thus prevents pest and disease incidence.

Providing sufficient gaps

While planting seedlings, a one-foot gap should be provided after every eight feet to enable sunlight to reach the lower segments of the plants. This reduces the incidence of pests that are found on the under surface of the crop. Such spacing also helps during the application of manures and the spraying of biopesticides.



Neekal podum murai

Provision for sunlight

Neekal podum murai is a traditional practice that has been followed in the Chengalpet district of Tamil Nadu for a number of years. In this method, women stand in a line in between the plants and walk from one end of the field to the other, pressing the under parts of the plants. This enables sunlight to reach the lower segments of the crop. The practice not only kills the nymphs of the brown plant hoppers sticking to the under surface of the plants but also helps to check the rodent population.

Rope method

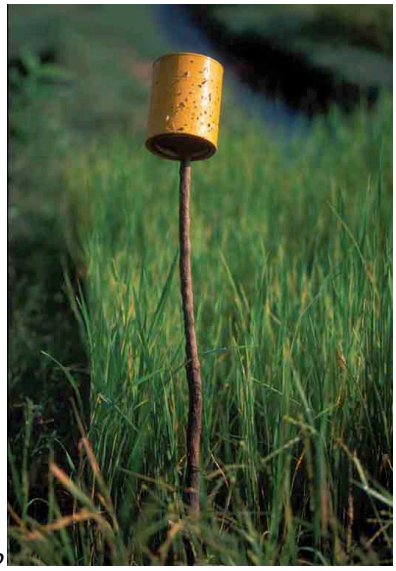
The field should be filled with water up to a height of 5 cm. One litre of kerosene should be mixed with 25 kg of sand and strewn in the field. Later, a string should be dragged over the surface of the

leaves vigorously so that the caterpillars fall into the water. The caterpillars are killed by the kerosene present in the water. Later, the water should be drained to remove the dead caterpillars.

The field should be dried and then freshly irrigated. This method should be used only during the vegetative stages of the crop.

Yellow sticky trap

An empty tin or a plate painted yellow and smeared with castor oil should be placed one foot above the crop canopy in the field. The adults of sucking pests that are attracted by the bright yellow colour get trapped in the oil smear. These pests should be wiped out every day and oil should be applied afresh.



Yellow sticky trap

Light trap

Light traps can be used to monitor and trap adult insects, thereby reducing their population. Some formal light traps that could be used are electric bulbs, hurricane lamps and bonfires. Water mixed with kerosene is filled in a large plate or vessel and kept near the light. The trap should be fixed 2–3 ft above the crop canopy and set up in the field between 6 and 9 pm. (If it is kept beyond 9 pm, there are chances that the beneficial insects will also get trapped and killed.) The adult moths, which get attracted by the bright light, fall into the water in the vessel and perish.

Light trap

Pheromone trap

About eight traps should be used per hectare. They should be placed two feet above the crop canopy. The level of the trap should be adjusted according to the plant height (1–2 feet above). A chemical called a 'pheromone' – obtained from female moths – is used in the pheromone trap to attract male moths. The latter are pulled into the trap by the pheromone and die.

Bird perch with yellow coloured rice to attract birds

Bird perches

'T' shaped bird perches should be erected in the field at the rate of 15–20 per hectare. They should be placed one foot above the crop canopy. These perches serve as resting places for the birds which feast on the larvae they find in the field.

Mix rice with the blood of a chicken, make it into pellets and broadcast these in the field. The smell of blood and rice attracts

predatory birds to the perches in the field from where they pick up the swarming caterpillars.

Use of effigies

A human-like figure, made of paddy straw and wearing a white dress (@ two effigies per hectare) kept in the field at milky to grain-filling stage, will scare away the birds.

Fumigation for disease control

Diseased crops can be sprayed with 10% cow urine solution. On the same day or the following day, fumigation should be carried out in the evening. About 200 gm of *vaividanga* (*Embelia ribes*) or sweet flag (*Acorus calamus*) is powdered well, put in a wide mouthed pot with burning charcoal and carried into the field in a direction opposite to the wind. On the seventh day after fumigation, sweet flag rhizome extract should be sprayed. This method controls bacterial and fungal diseases.

BIOLOGICAL METHODS

Use of plants with pest repellent properties

Leaves of neem, vitex, morinda, calotropis and jatropha are used for this purpose. Any two of the above mentioned leaves are taken and pounded well. The pounded leaves are put into mud pots and thrice the quantity of water added to them. The mouths of the pot are tied with a cloth and the pots as such are left aside for three days. The pots are then placed in all the four corners of the field. In the evening hours, the mouths of the pots are opened and the contents stirred well. The unpleasant odour which emanates from them will inhibit the entry of pests into the field.

Neem cake for pest control and manuring

Gunny bags filled with neem cake should be placed along the water channels. The neem cake gets dissolved in the water which irrigates the field. This practice prevents attacks from pests and diseases that affect the roots and tillers of the crop. The bags should be replaced once every 15 days.

Use of Cycas flowers

The flower of Cycas (*sannampu*) are cut into pieces, wrapped in straw and placed in the field @ 25–30 pieces /hectare. The odour

that is emitted from this flower prevents the entry of earhead bugs for two weeks. By this time, the milky stage is over and the grain matures without any interruption.

Preparation of botanicals

Neem-based products

Neem has been used from time immemorial as a bio pesticide. Various parts of the neem tree are used today in the making of botanical preparations.

Neem seed kernel extract

Good quality neem seed should be collected and pounded to remove its outer seed coat. It is next immersed in water (50 gm of kernel in one litre of water). After 12 hours, the solution should be filtered through a fine cloth and made up to one litre with the addition of water. The result can be used for direct spraying. About 350–450 litres of the solution are required for one hectare. Khadi soap solution @10 ml/litre (100 ml/tank) should be added as an emulsifier to help the spraying of solution in a uniform manner. The concentration of the extract can be increased or decreased depending on the intensity of the pest attack. The extract can be stored for a month.

The seeds used for preparing the extract should be at least three months old. When they are less than three months old or more than eight months old, their azadirachtin content will be less and the extract would be less potent and effective. The extract prepared should be milky white in colour. If it is prepared from aged seeds, the extract will be brownish in colour. NSKE is effective for a variety of leaf eating insects and can also be undertaken as a prophylactic measure.

Neem leaf extract

One kilo of neem leaves is crushed and soaked over night in five litres of water. Before spraying, the solution is strained and one ml

of soft soap solution is mixed per litre of extract. This solution is effective as a foliar spray against sucking and chewing insects. It can also be applied directly to the soil to control nematodes, especially in solanaceous crops. If the concentration of the solution is to be doubled, 2–2.5 litres of crushed leaves per litre of solution will have to be crushed and soaked.

Neem cake extract

100 gm of deoiled neem cake is taken to make each litre of aqueous solution. The cake should be kept in a cloth bag and hot water poured over it. The solution should be kept overnight in a covered container. This extract is very effective against all stem-boring insects.

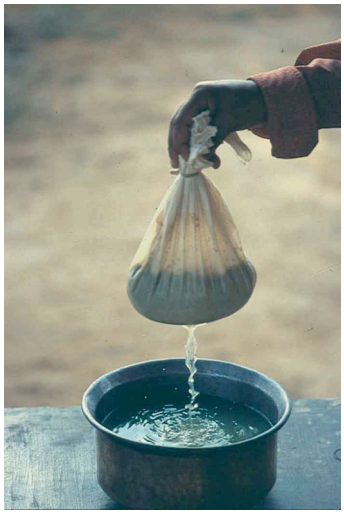
Neem oil

About 25 to 30 ml of neem oil is mixed with soap water to make an emulsion that can be sprayed for the control of fungal disease such as downy mildew. Neem oil solution is also effective against a wide range of pests such as beetles, plant hoppers, caterpillars, etc., but it can also harm some beneficial insects. Neem oil is mainly used to protect seeds during storage. About 5–10 ml of oil is mixed well with 500 ml of seed, before placing them in airtight containers.

Ginger, garlic, chili extract

Ginger, garlic, chili extract

For preparing an extract required for one hectare, 2.5 kg of garlic, 1.25 kg of ginger and 1.25 kg of green chili are first ground into a fine paste which is then diluted in about 18 litres of water and filtered. The concentration of the extract can be increased or decreased depending on the intensity of pest attack. It should be used immediately after preparation and can be stored for a maximum of three days.



Ginger, garlic, chili extract preparation

Five leaf extract

This extract is prepared using the leaves of five different plants. Leaves with the characteristics describeded below can be used for the purpose:

- Plants with milky latex – e.g., *calotropis, nerium*, cactus and jatropha.
- Plants which are bitter – e.g., neem, *andrographis, tinospora* and *leucas*.
- Plants that are generally avoided by cattle – e.g., *Adhatoda, Ipomea fistulosa*.
- Aromatic plants – e.g., vitex, ocimum.
- Plants that are not affected by pests and diseases – e.g., morinda, *Ipomea fistulosa*.

Any five of the above mentioned plant leaves should be collected in equal quantities (1 kg of each) and pounded well. Transfer this to a mud pot and add two times (10 litres) the quantity of water. To this, add one litre of cow urine and 100 gm of asafoetida. Tie the mouth of the pot tightly with a cloth. The extract should be mixed well daily every evening and used after a week after filtration. Cow urine is used for disease control and asafoetida prevents flower dropping, enhancing the yield.

Jatropha leaf extract

Collect 12.5 kg of jatropha leaves, pound and place in a mud pot. To this, add 12.5 litres of water and allow to ferment for 3–7 days. Filter and use the extract for spraying (after diluting with 10 parts of water) for one hectare area.

Sweet flag rhizome extract

Pound 10 gm of sweet flag rhizome to a coarse powder and add 50 ml of water. Leave the solution undisturbed for one hour and filter the sweet flag rhizome extract. For seed treatment, boil one litre of water and add 50 ml each of cow urine and sweet flag rhizome

extract the following day. Soak the seeds in water for six hours and then in the above solution for about 30 minutes. Filter the seeds, shade dry and sow. This procedure protects the seed against a number of bacterial and fungal diseases.

Turmeric rhizome extract

Shred one kilo of turmeric rhizomes. To this, add four litres of cow urine, mix well and filter. Dilute with 15–20 litres of water. For every litre of the mixture, add 4 ml of khadi soap solution. This helps the extract stick well to the surface of the plant.

Cow dung extract

Mix one kilo of cow dung with ten litres of water and filter using a gunny cloth. Dilute the solution with five litres of water and filter again. The result can be used for spraying.

Andrographis or *Sida kashayam*

Collect *Andrographis paniculata* or *sida acuta* leaves and wash first with tap water. Cut the materials into small pieces. Take a wide mouthed brass vessel, transfer the cut leaves to this vessel and add four parts (four times the quantity of leaves) of water. Boil them on a low flame until the contents are reduced to one-fourth the original volume (approximate time of boiling to get 500 ml of *kashayam* will be about two hours and 30 minutes). Pour the solution into a glass jar and allow it to cool for half an hour. After cooling, filter the solution using a khada cloth and add 1% sodium benzoate solution as preservative. About 500 ml of this solution is mixed with 100 ml of khadi soap solution and diluted in 9.4 litres of water for field spraying.

Eucalyptus or lantana leaf extract

Boil tender leaves of eucalyptus or lantana (1 kg in 1.5 litres of water). Cool the solution, filter the next day and dilute with 20 litres of water. About 350–450 litres of this solution can be used directly for spraying in a one hectare field area.

Indigenous innovations in microbial nutrients

Panchagavya

Panchagavya is a growth regulator produced from a combination of five products obtained from the cow along with a few other bioproducts. Collect fresh cow dung (5 kg), mix it with ghee (1 litre) and keep it in a plastic barrel separately for three days. On the same day, mix the other ingredients, namely cow urine (three litres), cow's milk (two litres), curd (two litres), yellow banana (400 gm, without skin), coconut water (three litres), jaggery (one kilo dissolved in three litres water) in a plastic barrel separately. Filter the jaggery solution before adding it to the other ingredients. On the third day, mix the contents of both the barrels and leave them aside for seven days. Stir the contents with a wooden stick twice a day. After seven days, filter the product with a khada or terracot (TC) cloth and store it in closed containers. (Pierce small holes in the cap of the containers to prevent bursting.) This is diluted @ 300 ml/10 litres water and sprayed.

Amirthakaraisal

Take fresh cow dung (10 kg), cow's urine (10 litres), country jaggery (1 kg) and water (100 litres) in a cement tank and mix well. This can be used the following day. Add this extract to the irrigation channel or spray directly. This improves the soil fertility and gives good yield.

Beejamrut

Ingredients

Cow dung	5 kg
Cow urine	5 lit
Cow milk	1 lit
Lime	250 gm
Water	100 lit

Mix all the ingredients and keep overnight. Sprinkle the formulation on seeds to be sown, then dry in the shade before sowing.

Jeevamrut

Ingredients

Cow dung	10 kg
Cow urine	10 lit
Jaggery (old)	2 kg
Flour of gram, pigeon pea, *moong* or cowpea or urid	2 kg
Live soil	1 kg
Water	200 lit

Take 100 litres water in barrel and add 10 kg cow dung + 10 litres cow urine. Mix well with the help of a wooden stick, add 2 kg old jaggery and 2 kg flour. Mix this solution well with a wooden stick. Keep the solution aside for fermentation for two to seven days. Shake the solution regularly three times a day.

Amrut pani

Mix 10 kg cow dung with 500 gm honey and mix thoroughly to form a creamy paste. Add 250 gm of ghee and mix at high speed. Dilute with 200 litres of water. Sprinkle this suspension in one acre over soil or with irrigation water. After 30 days, apply a second dose in between the row of plants or through the irrigation water.

BIOCONTROL METHODS

In this method, insects are used to control plant pests. Natural enemies of insect pests, also known as biological control agents, include parasites, predators, fungi, bacteria, viruses and other living agents.

These seek out and kill target insects that have become pests. They may be natural or genetically improved organisms.

Parasites

Parasites are organisms that live in or on the body of their host during some part of their life cycles. They are mostly flies or wasps that generally complete their development on a single host. Parasitic insects are responsible for controlling a number of pests. These beneficial insects either predate the pests or damage the different stages of insect development like egg, larva and pupa. These biocontrol agents are categorized as below:

Egg parasites

These parasites damage the egg stage of the harmful insect. Some of the commonly used egg parasites are *Trichogramma spp.*, *Telenomus spp.* and *Testrastichus sp.* These parasites control top shoot borer in sugarcane, internode borer in sugarcane, cotton bollworms, paddy stem borers, sorghum stem borers, etc.

Larval parasites

These parasites destroy the larval stages of pest insects. The classical example is *Bracon spp.* used in controlling black headed caterpillar in coconut and *Goppniozus nephantidis* used against the coconut leaf eating caterpillar.

Pupal parasites

The pupal stages of pests are destroyed by pupal parasites. *Testrastichus sp.* is widely used to control pests like American boll worm, paddy leaf rollers, black headed caterpillars, etc., in their pupal stages.

Predators

Predators like *Chrysopa sp*, *Menochilus spp.* are highly useful in controlling a wide variety of pests like aphids, whiteflies, cotton bollworms, leaf insects, etc. The eggs of these parasitoids are commercially available in the form of egg cards.

For example, the egg cards of the parasitoid *Trichogramma brasiliensis* are available commercially. Each egg card (e.g., *Trichogramma*) contains 20,000 live parasitised eggs which have 90–96% hatching potential within 7–10 days of parasitisation. These are applied @ 3–5 cards/ha. Each egg card cost Rs.20 to Rs.50. *Chrysopa sp.* is available in vials containing 1,000–5,000 live eggs/larvae. The standard recommendation for crops like cotton, sunflower, tobacco, groundnut, mustard and vegetables is 5,000–10,000 eggs/larvae per ha. Each vial cost Rs.150 to Rs.200.

Table: Commercially important microbial pesticides and biorationals used in India

S.No	Category	Products	Target pest	Major crops
1.	Bacteria	*Bacillus thuringiensis* *Bacillus sphaericus* *Bacillus subtilis* *Pseudomonas fluorescens*	Lepidoptera Mosquitoes, flies Fungal pathogens Fungal pathogens	Cotton, maize, vegetables, soybean, groundnut, wheat, peas, oilseeds, rice
2.	Fungi	*Trichoderma viride* *Trichoderma harzianum* *Trichoderma hamatum*	Fungal pathogens	Wheat, rice, pulses, vegetables, plantations, spices and sugarcane
		Beauveria bassiana *Verticillium lecanii* *Metarhizium anisopliae* *Paecilomyces lilacinus* *Nomuraea rileyi*	Insect pests such as bollworms, whiteflies, root grubs, tea mosquito bugs.	Cotton, pulses, oilseeds, plantation crops, spices and vegetables
3.	Viruses	Nuclear polyhedrosis virus (NPV) of *Helicoverpa armigera, Spodoptera sp.* and *Chilo infescatellus*	American bollworm, tobacco caterpillar and shoot borer	Cotton, sunflower, tobacco and sugarcane
4.	Biorationals	Pheromone traps, Pheromone lures, sticky traps and mating disruptants	*Bactocera sp.* *Chilo sp.* *Dacus sp.* *Earias vittella* *Helicoverpa armigera* *Leucinodes orbonalis* *Pectinophora gossypiella* *Plutella xylostella*	Cotton, sugarcane, vegetables, fruitcrops

Source: A Thimmaiah, *Current State of Inputs for Organic Agriculture.*

Microbial pesticides

The use of microorganisms as biocontrol agents is gaining importance in recent years. Biopesticides are living organisms or their derived parts which are used as bio-control agents to protect crops against insect pests. Entomopathogenic viruses of baculovirus group, bacterial insecticides, particularly *Bacillus thuringiensis*, entomo-fungal pathogens, protozoans and insect parasitic nematodes have been found to control important pests of crops.

These biopesticides are commercially available and are quite difficult to formulate in field conditions.

Types of microbial biopesticides

Bacterial biopesticides

Fungal biopesticides

Viral biopesticides

Method of application of biopesticides

Seed treatment: 10 gm/kg of seed

Nursery bed: 1 kg/100 kg soil mix

Soil drenching: 10 gm/litre of water

Seedling dip (30 min): 10 gm/litre of water

Soil application: 5 kg/acre with FYM

Foliar spray: 1 kg/acre

Seed treatment with *Pseudomonas fluorescens* and *Trichoderma viride*

Pseudomonas fluorescens and *Trichoderma viride* (5 grams each per 100 gm of seeds) should be mixed with one litre of cooled rice gruel. The sprouted seeds required for one hectare should be spread on a clean floor and the bio-agents should be sprinkled over the seeds and mixed well.

***Trichoderma viride* (TV)**

Trichoderma viride is a fungus with multipurpose use in agriculture. As a biological pesticide, it is useful in fungal attack like wilt, rusting of leaves and root rot disease. It helps in germination of seed. It can enhance the growth of the plant and partly satisfies the nutrient requirements of the plant. TV is not harmful to either plants or animals.

Seed treatment

- Seed must be washed first to get rid of any chemical fertilisers and pesticides.
- TV culture is taken @10 gm per kilo of seeds.
- The culture is mixed with starch to make it sticky.
- Seeds are coated with the paste and dried in the shade.
- The dried seeds are sown the same evening.

Seedling treatment

- 20 gm of TV is mixed in a litre of water.
- The seedlings of brinjal, chili, tomato, cabbage, etc., are immersed in this mixture for five minutes before transplantation.
- For nursery treatment, 50 gm of TV culture is mixed with 500 gm of vermicompost or compost and mixed in 64.8 m2 of land.

INSTITUTIONS INVOLVED IN PROMOTING RESEARCH, TRAINING AND DOCUMENTATION FOR PADDY, GROUNDNUT, OKRA AND TOMATO

National Research Centre for Groundnut, P.O. No.5, Ivnagar Road, Junagarh – 362001, Gujarat.

AICRP on Groundnut, NRC for Groundnut, Junagarh – 362001, Gujarat

Directorate of Oilseed Research, Hyderabad – 500030, Andhra Pradesh

AINP on White Grubs and other Soil Arthropods, RAU, Agri. Res. Station, Durgapura, Rajasthan.

Indian Vegetable Research Institute, Varanasi, Uttar Pradesh – 221005.

Indian Institute of Horticultural Research, Hassarghatta, Lake Post, Bangalore.

AICRP on vegetables, IIVR, Varanasi.

Indian Agricultural Research Institute, Pusa, New Delhi – 110012.

Research Stations and KVKs of State Agriculture Universities.

Directorate of Rice Research, Hyderabad – 500030.

IARI: Rice Breeding Genetics Research Centre, Aduthurai, Tamil Nadu

Central Rice Research Institute, Cuttack – 753006, Orissa

AME, Bangalore.

REFERENCES

Anon. 2001. *Bio-Manure: Rural Industry for Organic Farming*, Directorate of Non-Conventional Energy & Bio-Technology Cell, Khadi and Village Industries Commission, Mumbai.

Anon. 2002. *National Programme for Organic Production*, Department of Commerce & Industry, New Delhi.

Anonymous. 1996. *Groundnuts*. Natural Resources Institute, United Kingdom. p. 348.

Arumugasamy, S., M. Jayashankar, K. Subramanian, S. Subhashini and K. Vijayalakshmi. 2001. *Indigenous Rice Varieties*. Centre for Indian Knowledge Systems, Chennai, p. 74

Bhardwaj, S. P, Prasad, S. N. and Singh, G. 1981. 'Economizing nitrogen by green manures in rice-wheat rotation,' *Indian Jour. Of Agric. Sci*, 51:86–90.

Bhattacharyya, P. 2004. Organic Food Production in India, Status, Strategy and Scope. Agrobios, India.

Bourguignon, C. 2005. *Regenerating the soil: From agronomy to agrology*. Other India Press, Goa, India.

Chadha, K.L. (ed.). 2001. *Handbook of Horticulture*. ICAR, New Delhi, p.1031

Chatterjee, B. N., Singh, K.I., Pal, A and Maiti, S.1979. 'Organic manure as substitute for chemical fertilizers for high yielding rice varieties.' *Indian Jour. Agric. Sci*, 49:188–92.

Chaudhary, T. N, Wood head, T. Ladha, J. K. and Baghel, S.S. 1994. 'Green manuring in dry seeded rice on submergence-prone rain fed lowlands of eastern India.' Ed: J. K. and D. P. Garrity. *Selected papers from Int. Rice Res. Conf.* IRRI Pub. Philippines.

Choudhury, B.1998. *Vegetables*. National Book Trust, New Delhi, p.230

Crop Production Techniques of Horticultural Crops. 1999. TNAU, Coimbatore, p.260

Damodaram, T. and D.M. Hegde. 2000. *Oilseeds situation – A statistical compendium*. Directorate of oil seeds research, Hyderabad. p. 383.

Deshpande, M.S. 2003. *Organic Farming wrt Cosmic Energy Non Violence Rishi-Krishi* Mrs Pushpa Mohan Deshpande Kolhapur.

Devasagayam, H.L. 2002. *Payirgalai Thakkum Poochigalum Peedaigalum (Crop Pests)*. Zion Printers & Publishers, Chennai. p. 478.

Devasakhayam, H.L. 2001. *Payirkalin Noikal*. Zion publishers, Chennai, p.647

Gour, T.B. et al., 2000. *Tomato, brinjal, okra – Insect pests, diseases, nutritional disorders*. Acharya N.G. Ranga Agricultural University, Hyderabad, p.92

Gour, T.B., T. Ratnasudhakar, T. R. Babu, K. C. Rao and A. P. Rao. 2003. *Rice – Insect pests, diseases, nutritional disorders*. Agricultural Technology Information Centre NATP, ICAR, Hyderabad, p. 60

Handbook of Agriculture. 1997. Published by Indian Council of Agricultural Research, New Delhi, pp.760–790

'Honey Bee' – A bimonthly journal published by Sristi Innovations, Ahmedabad. 1990–2000

Indian Horticulture Database 2003. 2004. National Horticulture Board, Gurgaon, p.27, 159–162

'Indigenous Agriculture News.' Bimonthly newsletter published by Centre for Indian Knowledge Systems, Chennai

Inventory of Indigenous Technical Knowledge in Agriculture. Document 1 – 3. 2003. ICAR, New Delhi

Jayashankar, M., K. Subramanian, S. Arumugasamy, H. Saraswathy & K. Vijayalakshmi. 2002. *Soil Conservation in Organic Farming – Hand book 1*. Centre for Indian Knowledge Systems, Chennai, p. 30

Jayashankar, M., S. Arumugasamy, H. Saraswathy and K. Vijayalakshmi. 2002. *Indigenous Rice Varieties – 2*. Centre for Indian Knowledge Systems, Chennai, p. 100

Kak, R.D. 1995. *Groundnut in India*. Publications & Information Directorate and Wiley Eastern Limited, New Delhi. p. 126.

Krishan, C., Greep, S., Rupela, O.P., Gupta, A.P. and Kapoor, K.K. 2005. 'Is High Yield Possible with Biological approaches? Management of Organic wastes for Crop Production,' Department of Microbiology, CCS Haryana Agricultural University, Hisar – 125004.

Krishan, C, Greep, S. and Srivathsa R.S.H. 2005. *Biocontrol Agents and Biopesticides (Liquid Formulations)*. Regional Centre of Organic Farming, Bangalore, Department of Agriculture, GOI.

Kumar, A.K. and Mathew J. 1994. 'Timing of green manuring in presence and absence of liming on growth, yield and nutrient uptake in transplanted rice (*Oryza sativa*).' *Indian J. Agron*, 39 (4): 630–3.

Lanting, H., Rao, M.S. and K.Ravi. 2001. *Tomato – a field guide to ecofriendly crop protection*. AME, Bangalore, p.52

Lingappa, S., Shekharappa and R.K. Patil. 2003. *Integrated Pest Management*. Publication centre, University of Agricultural Sciences, Dharwad. Pp.100.

Mehla, D.S. 1989. *Green manuring of Sesbania aculeate in rice-wheat system*, seasonal report (NARP), Kaul (HAU).pp.3–4.

Nagarajan, S.S. 1977. *Nel Saagupadi*. Cre-A, Chennai, p. 256

Nagarajan, S.S. 1985. *Kaar Kuruvai Sornavari Pattangalil Nel Sagupadi*. Dinamani Veliyedu, Chennai, p. 95

Pant, R.K. 2004. Organic Farming: A Tool for Trainers, DASP-Uttaranchal

Pathak, M. D. 1973. 'Developing an integrated method of rice insect pest control.' *PANS*. 19:534–44.

Pathak, R. K. and Ram, R. A. 2004. *Manual on Jaivik Krishi*, CISH, Lucknow.

Rai, M., Singh, M., Pandey, P., Pandey, K.K., Singh, J., Kumar, S. and Singh B. 2006. *IIVR: A decade of accomplishments*. Indian Institute of Vegetable Research, Varanasi.

Rai, M., Kumar, S., Singh. M. and B. Singh. 2004. *Popular varieties of vegetables in India*. Indian Vegetable Research Institute, Varanasi.

Raj, D.A. 2003. *Paddy: Guidelines for Eco-friendly Cultivation*. AME Foundation, Bangalore, p.64

Rangaswami, G. 1999. *Diseases of Crop Plants in India*. Prentice hall of India Pvt. Ltd., New Delhi, p.536

Rangaswami, G. and A. Mahadevan. 2001. *Diseases of Crop Plants in India* (Fourth edition). Prentice Hall of India Private Limited, New Delhi, p.160–188

Reddy, D.D.R. et al. 1999. *Groundnut: Insect pests, diseases, nutritional disorders*. Acharya N.G. Ranga. Agricultural University, Hyderabad. p. 58.

Reddy, P.S. (Ed). 1998. *Groundnut*. Indian Council of Agricultural Research, New Delhi. p.583.

Richharia, R.H and S. Govindaswami. 1990. *Rices of India*. Academy of Development Science, Maharashtra, p. 350

Rupela, O.P., Humayun, P., Venkateswarlu, B and Yadav, A. K. 2006. *Comparing Conventional and Organic Crop Production Systems: Inputs, Minimal Treatments and Data Needs*, Organic Farming Newsletter, NCOF, Ministry of Agriculture, GOI.

Sastry, K.S.M. and S.J. Singh. 1974. 'Effect of yellow vein mosaic virus infection on growth and yield of okra crop.' *Indian Phytopath*. 27: 294–297.

Selvaraj, N. 2006. *Resource Manual*. Brainstorming Conference on Organic Agriculture organized at Horticultural Research Station, Ooty, Tamil Nadu

Singh, R.S. 1999. *Diseases of Vegetable Crops*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, p. 406

Singh, R.S. 2003. *Plant Diseases*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, p. 686

Sridhar, S. Arumugasamy, S. and Saraswathy, H. and Vijayalakshmi, K., and. 2003. *Organic Vegetable Gardening*, Centre for Indian Knowledge Systems, Chennai, p.46

Stoll, G. 1986. *Natural Crop Protection in the Tropics*. Agrecol. Germany, p. 188

Subhashini, S. and K. Vijayalakshmi. 2002. *Neem: A User's Guide*. Centre for Indian Knowledge Systems, Chennai, p. 50

Subrahmaniyam, P. and et al. 1992. 'Field Diagnosis of Groundnut Diseases.' *Information Bulletin* No. 36. ICRISAT, Andhra Pradesh, p. 79.

Subramanian, M. 2003. *Iyarkai Muraiyil Nel Sagupadi*. Naveena Velanmai, Chennai, p. 57

Subramanian, M. *A Manual on Nellukku Uyir Urangal*. Tamil Nadu Nel Aaraichi Nilayam, Aaduthurai Tamizhaga Vivasaaya Ulagam, Feb. 2005

The Wealth of India series. 1985. CSIR, New Delhi

Vijayalakshmi, K., Arumugasamy, S. and S. Sridhar. 2003. *Organic Methods of Pest and Disease Management*, Centre for Indian Knowledge Systems, Chennai

Vijayalakshmi, K., Devi, T.D.N., Subhashini, S. and S. Arumugasami. 2004. *Organic Paddy Cultivation*. Centre for Indian Knowledge Systems, Chennai, p. 102

Vijayalakshmi, K., Subhashini, S. and E. Damodharan. 1998. *Rice – Non-chemical Methods of Pest Control*. Centre for Indian Knowledge Systems, Chennai, p.54

Wightman, J.A. and G.V. Ranga Rao. 1993. *A groundnut insect identification handbook for India*, Andhra Pradesh. p. 60

Wightman, J.A., H. Lanting and Rama Devi Kolli (Eds). 1998. 'Ecofriendly Management of White grub and Leaf miner Pests of groundnut' – *Proceedings of a diagnostic workshop*. Agriculture Man Ecology, Karnataka and National Institute of Agricultural Extension Management, Andhra Pradesh. p. 102

Yadav, A.K. and Mowade, S.M. 2000. *Organic Farming: A Ray of Hope for Indian Farmer*, ed. National Biofertilizer Development Centre, Ghaziabad.

Yennai vithu payirkalil vithai urpathi thozhil nutpangal – 2002. TNAU, Coimbatore.

Yennai vithukalil munodi vivasayam, 1998, Tamil Nadu cooperative oil seeds producers union limited, Neyveli.

Web sources

www.atmachittoor.com

www.agbioworld.org

www.ciks.org

www.ficciagroindia.com

www.fao.org

www.fao.org.in

www.ikisan.com

www.icar.org.in

www.irri.org

www.iari.res.in

www.kissankerala.net

www.krishiworld.com

www.kau.edu

www.oisat.org

www.pnbkrishi.com

www.seedtamilnadu.com

www.tnau.ac.in

www.webindia123.com